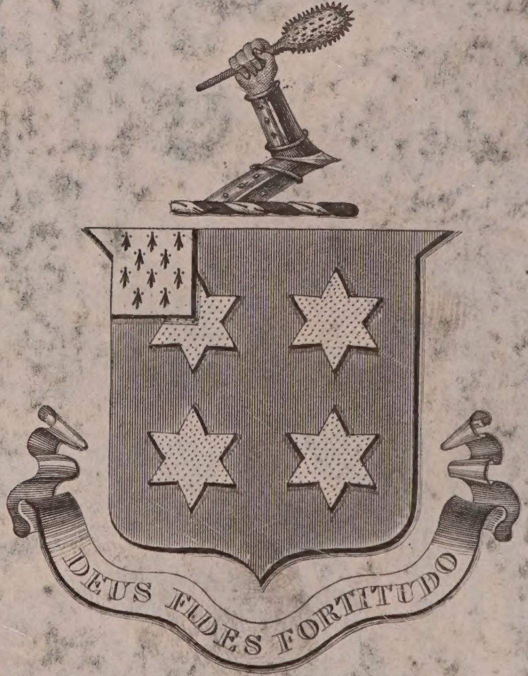


Thomas Westwood.

48806|B

2 vols 7/6

Smith
Godfrey

THE

LABORATORY;

OR,

SCHOOL OF ARTS:

CONTAINING

A LARGE COLLECTION OF VALUABLE

SECRETS, EXPERIMENTS, AND MANUAL OPERATIONS,

IN

ARTS AND MANUFACTURES;

HIGHLY USEFUL TO

GILDERS,	GOLDSMITHS,	PEWTERERS,	BOOK-BINDERS,
JEWELLERS,	DYERS,	JOINERS,	PLASTERERS,
ENAMELLERS,	CUTLERS,	JAPANNERS,	ARTISTS,

AND TO THE WORKERS IN METALS IN GENERAL;

AND IN

PLASTER OF PARIS, WOOD, IVORY, BONE, HORN, AND OTHER MATERIALS.

COMPILED ORIGINALLY BY

G. SMITH.

SEVENTH EDITION,

WITH A GREAT NUMBER OF ADDITIONAL RECEIPTS, CORRECTIONS, AND AMENDMENTS; A COMPLETE TREATISE ON FIRE-WORKS, AND THE ART OF SHORT-HAND WRITING. THE WHOLE ADAPTED TO THE PRESENT IMPROVED STATE OF SCIENCE.

ILLUSTRATED WITH ENGRAVINGS.

VOL. I.

LONDON:

PRINTED BY LAW AND GILBERT,
St. John's Square, Clerkenwell,

FOR SHERWOOD, NEELY, AND JONES; R. SCHOLEY; LONGMAN, HURST, REES, AND ORME; AND J. WALKER, PATERNOSTER ROW: VERNOR, HOOD, AND SHARPE, POULTRY: CROSBY AND CO. STATIONER'S COURT; AND C. BROWN, WILD STREET, LINCOLN'S INN FIELDS.

1810.

PREFACE

TO

THE SIXTH EDITION.

THE arts have so necessary a dependance on each other, that it would be an useless task to endeavour to point out their advantage to mankind. Daily experience, and indeed the mere operation of our senses, confirm the impossibility of detailing the utility which must result from the publication of human inventions. The rapid progress of the physical sciences has been the occasion of much labour to the learned, whose works have been often rendered useless by the appearance of new volumes, and has given rise to many compilations and abridgments. But for these compressions of matter into reasonable bounds, in the forms of Dictionaries and Encyclopædias, the diffusion of knowledge would be less extensive, because the price would be too high for the generality of

 readers,

readers, and discoveries would chance to remain scattered and uncollected.

But whilst the succession of every year may have thrown a light upon the principles of many facts which were before unknown to us, we should take heed that many of the facts themselves do not escape us. The history of former ages has furnished the woful certainty of the loss of many arts, which the unwearied attention of succeeding times may be long in restoring. Had the simple manual of every art been recorded, without attempting to bewilder by the addition of theory, we should probably be in the possession of what we may wistfully require in vain. Of these valuable secrets which have been lost, the one of rendering *glass malleable*, is alone sufficient to demand our regret.

The original plan and intention of the work which is now announced to the Public, was to disseminate, in a reasonable way, what had been collected at great cost and expence; such as the secret methods of working which were practised by artists in their several employments, and various other valuable receipts.— With the same view, this new edition appears, which is no fewer than *the sixth* from its first publication.

Why

Why a work of so distant a date is still held in such great request, is owing to the reasons assigned above, that *it is a repository of many operations which are employed at this very time*, free from theoretical descriptions, and therefore intelligible to the meanest capacity.—Moreover, the terms of art, and the names of the several ingredients, are conformable to those in *common use*, and such as on enquiry at druggist's shops will be known and sold under those titles.

A work of this kind is ever useful, although it be not adapted to the reading of philosophical students; for unless some such publications are afloat, philosophers themselves, in distant periods, would be deprived of the very materials of their own labours: it is by the established custom of tradesmen following the occupation of their fathers, that the manual arts have been preserved in the East.

Many of the passages in this edition will be found entirely expunged, by comparing it with former ones: many of them are abridged; most of them are corrected; and a variety of new matter is added. Sometimes whole paragraphs, and even chapters, have been transposed; which has been purposely done, to arrange it in a series more orderly and con-

venient.

venient. The chapter on Fire-works, for instance, *here* begins the work, because it forms one of the earliest amusements of youth, and will be likely to employ their first attention to experiment; thence, gradually acquiring a manual expertness, they will be led to undertake more elaborate operations, and be initiated in a fondness for philosophy. For the retention of some peculiarities, such as *the usual and ordinary appellations of drugs and chemicals*, in lieu of modern philosophical names, a fair reason has been assigned; and, indeed, to employ new terms would totally defeat the intention of the work, which is compiled for a valuable class of men, whose operations must be couched in their own technical terms. *Quickening* is a singular expression to be employed in gilding; but water-gilders are accustomed to the phrase, and employ it constantly. *Black-lead pencils* are also known to every class of society, independent of artists who are more acquainted with their use; yet it is a notorious fact that they have not a particle of lead in their composition *. Some terms, then, cannot be corrected, unless a display of knowledge be preferred to the more valuable requisite of being intelligible.

* What was supposed, by the old chemists, to be *black-lead*, is now well known to be a compound of *iron*; called *carburet of iron*, in modern chemical language.

It

It must be confessed, indeed, that a number of the receipts might have been corrected; but it has been thought better to retain those which are left nearly in their original state; omitting such as are impracticable at the first glance, and making additions to the original stock; for this reason, that many of them are still in request by workmen, whose time is principally busied *in effects*, and are little observant and anxious of the causes of such effects. By the addition of new processes, in lieu of entirely expunging the old, another advantage will accrue—that the methods of working formerly known, will still be in preservation, whereby a basis is left for improvement, by the ingenious, as the theory of the arts is gradually unfolding. The just and obvious objection to obsolete experiments is, therefore, in some measure removed; and it is hoped, that the large class of young people, whom these recreations concern, may find the amusement and instruction which it is so much their interest to cultivate.

Before a final close is put to the above observations, it may be proper to remark, that a useful treatise has been introduced, in this edition, on the practice of *Short-hand writing*. When a quick and easy mode of committing either

either our own thoughts, or those of others, to the safe-guard of manuscript, is attainable, no one surely will forego the application of a few hours to the occasional practice of the art! A thousand thoughts which daily strike us may be thus instantly preserved from destruction, to the future benefit of ourselves, and the probable benefit of posterity: and if our ideas be, at first, crude and undigested, which will be too frequently the case in sudden flights of imagination, they will be recorded in symbols of more than ordinary usage, of course, free from observation till matured by time.

ADVER-

ADVERTISEMENT

TO THE

SEVENTH EDITION.

THE Editors of the new Edition of the "Laboratory" have taken still greater liberties with the volumes consigned to their care than their predecessors*. Upon an attentive and diligent examination of the work they were satisfied that a considerable portion of it, by new discoveries in science, and the publication of recent processes and experiments in the arts, had become nearly obsolete, and might very properly give place to matter more generally useful. They have accordingly suppressed several whole articles, and a great number of detached sections, the place of which they have supplied by a still larger quantity of matter compiled from works of reputation and authority.

* See Preface to the Sixth Edition.

authority. To those who are acquainted with the former editions of the "Laboratory," it will be seen that the present is in many respects re-arranged, and that a part of the plates are entirely new, to correspond with articles drawn up to supercede those which are suppressed.

As it was the wish of the proprietors, so it has been the aim of the editors to render the "Laboratory" what its title imports, a "School of Arts," adapted to instruct young persons and others in the elements of science, and in various processes used in trade and manufactures. With this view many of the separate parts are now introduced, with an account of the principles on which the particular art or operation is conducted. This, it is presumed, will give a value to the "Laboratory" to which it had no prior claim; and, it is hoped, that in other respects it will continue to maintain its rank in the public esteem, which six successive impressions shew that it has hitherto held.

The concluding parts of both volumes are new, and drawn up on such a plan of practical utility in the way of experiments, and domestic concerns, as will render them useful as an introduction to chemical analysis and discovery, and as works of reference in many of the ailments to which the branches of a family are liable. They will, at the same time, serve as a guide to the proper management of some of the most important, because most frequently repeated, operations of domestic life.

As

As the editors of this impression of the "Laboratory" lay claim to no higher praise than that which industry naturally confers, they feel it a duty and a pleasure to refer to those excellent works by which they have been materially assisted: these are, the Dictionaries by Rees, Aikin, and Nicholson; Thomson's, Parkinson's Murray's, and Henry's Chemistry; Haüy's Natural Philosophy, Hooper's Recreations, &c. &c.

CONTENTS.

Page

PART I. Of Artificial Fire-Works 1

Description of various Instruments for Chemical Operations 65

Of Lutes 75

PART II. Experiments on Gold and Silver; including brief Histories of those Metals, and Descriptions of the Arts of Gold-beating, Wire-drawing, and Gilding 81

PART III. The Art of Enamelling, including the Method of preparing the Colours; of making and cleaning Artificial Pearls, Doublets, Foils, Gems, &c. 139

PART IV. The Art of Glass-making, with various Receipts for the different Kinds of Glass: Painting on Glass 189

Pottery and Porcelain Manufactory; with the Arts of Painting, Glazing, &c. 225

PART V. Directions for Casting, or taking Impressions; with Receipts for casting in Silver, Copper, Brass, &c. 238

Mixtures for casting Mirrors 257

PART VI. Mechanical Arts; including Accounts of, and Receipts for, Smiths, Cutlers, Pewterers, Braziers, Book-binders, Joiners, Turners, &c. 261

PART VII. Water-works, Fountains, Grottos, &c. 307

PART VIII. The Art of Dialling; with the Methods of constructing the several kinds of Dials 317

PART IX. Of Optics, and Optical Experiments 332

PART X. Stenography; or the Art of Short-Hand Writing: including "the Universal Regulator of Work and Workmen" 355

PART XI. Of Snuff-making and Tobacco: Papier-Maché, Japan-Ware, Flock-Paper 359

PART XII. Of Writing Inks: Method of removing Stains of Ink, Wine, Grease, &c.—Cements, Glues, Size, &c. 377

PART XIII. Chemical Action: Chemical and other miscellaneous Experiments 391

ERRATA TO VOL. I.

Page 357. line 6. *for* XVIII. *read* XV.
22. XVII. XIV.

ERRATA TO VOL. II.

On Plate 15, line 1, *for* " and Plate 21," *read* and Plate XVI.

DIRECTIONS FOR THE BINDER.

The Binder is requested to insert the Plates in the following Places.

VOL. I.

Plate 1	- - - - opposite page	24
2	- - - - - -	48
3	- - - - - -	60
4	- - - - - -	72
5	- - - - - -	204
6	- - - - - -	216
7	- - - - - -	310
8	- - - - - -	314
9	- - - - - -	316
10	- - - - - -	330
11	- - - - - -	350
12	- - - - - -	354
13	- - - - - -	356
14	- - - - - -	358
15	- - - - - -	360

VOL. II.

Plate 1	- - - - opposite page	78
2	- - - - - -	108
3	- - - - - -	112
4	- - - - - -	128
5	- - - - - -	132
6	- - - - - -	134
7	- - - - - -	136
8	- - - - - -	138
9, 10, 11, 12, 13, 14	- - -	140
15 and 16	- - - - -	356

STEPHENSON'S LAND SURVEYING.

Lately publiſhed, in one volume 4to, Second Edition; Embelliſhed with an Engraved Plan, and Six Plates: together with an Engraved Field Book of 27 Pages; Price 16s. Half bound.

THE SYSTEM OF LAND SURVEYING AT

present adopted by Surveyors and Commiſſioners in Old and New Incloſures, conducted as an actual Survey, on a Plan conſiſting of open Fields, Ings, Common and Old Incloſure, divided and allotted according to Conditions and Agreement between the ſeveral Proprietors.

Treating of the Quality, and Quality Lines
Taking Particulars
Proprietors and Occupiers Names
Book of Particulars
Elplanation of Characters uſed in the Field Book, &c.
Ranging the Poles
Running the Lines
Laying the Lines upon the Plan
Plotting
Valuing by the Commiſſioners
Caſting
Taking Dimenſions
Finding the Content, &c.
Book of Dimenſions, Caſtings, &c.

Dividing into allotments—New Drains—New Roads—Stone and Sand Pits—Allotting the Fields, Common, Ings, &c.—Old Incloſure—Setting off upon the Plan each Proprietor's Quantity, according to their proportional Value—On the Fields, Commons, Ings, &c.—The ſetting and ſtaking out Allotments, Roads, Drains, Sand-pits, &c. &c.

To which are added Rules, ſhewing in what Manner Lines may be meaſured, where there are Impediments, or not, to obſtruct the Sight, ſuch as Buildings, Water, &c. Taking Diſtances; meaſuring on the Outſide of any Quantity of Land or Water, and thereby find the content: ſurveying large Towns, Cities, &c. Likewiſe, the proper Method to be purſued in meaſuring detached Pieces of Land where Plotting is not required.

The Whole by the Chain only.

By WILLIAM STEPHENSON, Land Surveyor, Horncaſtle.

London: Printed for Sherwood, Neely, and Jones, No. 20, Paternoſter-Row.

☞ This Treatiſe divulges what has hitherto been kept a Secret from the Public, ſcarcely known to any than its Profeſſors, and is ſo eaſy, that a Youth may teach himſelf, in a ſhort Time, as no Mathematical Inſtrument is uſed; and Gentlemen, not having Leiſure to make it a Study, may by referring from the Book to the Plan, and other Plates, become acquainted with the proceedings of Surveyors and Commiſſioners, and Plans in general, ſo eſſential to every one intereſted in Agricultural Purſuits, &c.

*** The Editor of the Annual Review, after deſcribing Mr. Stephenſon's method of allotments, ſays, " the inſtance is well made, and the practice upon it will give the learner a complete inſight into the buſineſs. The number of plates accompanying this work will be found very uſeful to the young land-ſurveyor."

THE

LABORATORY:

OR,

SCHOOL OF ARTS.

PART I.

ARTIFICIAL FIRE-WORKS.

As the principal ingredient in Artificial Fire-works is compounded of three substances, of the nature of which the reader may not be acquainted, we shall set out with giving a short account of gunpowder, and its component parts—Nitre, Sulphur, and Charcoal.

Gunpowder is so well known by its effects, as to render it unnecessary to give any particular description, further than to state, that it is an intimate mixture of seventy-five parts of purified nitre, ten parts of sulphur, and fifteen parts of charcoal. Many other proportions have been employed, but the above are found to succeed, for general uses, better than any other; because its force and goodness greatly depend on the total decomposition of the nitre, and the rapidity with which it is performed. The accuracy and intimacy of the mixture must of course be as great a requisite as the very ingredients themselves; and the combination is attended with no small degree of danger. In large manufactories, a mill is

employed, in which wooden mortars are disposed in rows, and in each of which is a wooden pestle, moved by the arbor of a wheel turned by water, or wind. The materials are pounded and mixed in these wooden mortars, for twelve hours together, being occasionally moistened during the trituration, to prevent any sudden explosion. Nothing now remains, after the above operation, but to form the powder into grains, which is found wonderfully to improve its powers, and render it less liable to soil the fingers, or foul the barrels of fire-arms:—the grains are made larger for cannon, and smaller for muskets. No process can be well imagined more simple than the granulation of the powder. It is placed to a certain thickness upon sieves, the holes of which are of a certain diameter, and a flat piece of wood is horizontally pressed upon the surface of the powder. The powder being damp when taken from the mill, for the reasons stated above, is readily formed into molecules of the size of the holes, and its surface rendered smoother, less liable to adhere to the surfaces of other bodies, and admitting a freer contact of atmospherical air between its particles. A still greater smoothness, and even lustre, is given to it, by putting a portion into a barrel, which turns upon an axis, by means of wheel-work, and produces a certain degreee of friction. After this, the whole grains are separated from the finer powder, by sifting it; and the finer powder is again granulated, and finished like the rest. The strength and goodness of powder are judged of in several ways, namely, by the colour and feel, by the flame when a small pinch is fired, and by measuring the actual projectile force by the eprouvette, and by the distance to which a given weight will project a ball of given dimensions under circumstances in all cases exactly similar. When powder rubbed between the fingers easily breaks down into an impalpable dust, it is a mark of containing too much charcoal, and the same if it readily soils white paper when gently drawn over it. The colour should not be absolutely black, but is preferred to be more of a

dark

dark blue with a little cast of red. The trial by firing is thus managed; lay two or three small heaps of about a dram each on clean writing-paper, about three or four inches asunder, and fire one of them by a red-hot iron wire: if the flame ascends quickly with a good report, sending up a ring of white smoke, leaving the paper free from white specks and not burnt into holes, and if no sparks fly off from it, setting fire to the contiguous heaps, the powder is judged to be very good, but if otherwise, the ingredients are either badly mixed or impure. The common eprouvettes or powder-triers are small strong barrels, in which a determinate quantity of the powder is fired, and the force of expansion measured by the action excited on a strong spring or a great weight. Another method often adopted is to fire a very heavy ball from a short mortar, with a given weight of the powder, and to find the range of projection. The French eprouvette for government powder is a mortar of seven inches (French) in calibre, which with three ounces of powder should throw a copper globe of 60 pounds weight to the distance of 300 feet. No powder is admitted which does not answer this trial. Both these methods have been objected to, the former because the spring is moved by the instantaneous stroke of the flame and not by its continued pressure, which is somewhat different; and the other on account of the tediousness attending its use when a large number of barrels of powder are to be tried. Another method which unites accuracy with dispatch, is to suspend a small cannon as a pendulum, to fire it with powder only, and to judge of the force of explosion by that of the recoil, which in this circumstance is a greater or less arc of a circle. That which Dr. Hutton employs on this principle is a small cannon about one inch in the bore, the charge of which is two ounces of powder. A very considerable variation is found in the proportions of the ingredients of the powder of different nations and different manufactories, nor is it exactly ascertained whether there is any one proportion which ought always to be adhered to,

 and

and for every purpose. The government powder made in this country is the same for cannon as for small arms, the difference being only in the size of the grains, but in France it appears that there were formerly six different sorts manufactured, namely, the strong and the weak cannon powder, the strong and the weak musquet powder, and the strong and the weak pistol powder. Many cases may occur in which it will be desirable to ascertain the proportions of the materials used in any given quantity of powder. The analysis of gunpowder performed with sufficient accuracy for most practical purposes is very easy and simple, but an absolutely accurate analysis is more difficult. The usual way is first to boil the powder with three or four times its weight of water, edulcorating it with more hot water till no saline taste remains. This extracts the nitre only, the quantity of which may be ascertained either by drying the residue and estimating as nitre all the loss of weight, or more directly by evaporating the watery solution. If the residue, consisting of the sulphur and charcoal, is now spread on an earthen plate of any kind and slowly heated, the sulphur takes fire, and burns off gradually, whilst the charcoal remains untouched, when the heat is kept down sufficiently. Beaumé found, however, that when all the sulphur is expelled which will be driven off in this heat, a certain portion will still remain and will not burn away at a lower temperature than will consume the charcoal, so that to the last the burning residue will smell strongly sulphureous. This retained portion of sulphur he finds by the results of many other experiments to be very uniformly about one twenty-fourth part of the whole sulphur employed, whence for all common purposes an adequate correction may be made by estimating that the slow weak combustion of the residue, after the nitre has been got out, destroys only $\frac{23}{24}$ths of the sulphur instead of the whole. On trying to separate them by an alkaline solution, he found some of the sulphur to remain undissolved and still adhering to the charcoal. The way to ensure perfect accuracy in the analysis would be

first

first to separate the nitre by hot water, then to acidify all the sulphur by the nitric acid, to dissolve and to precipitate it by a solution of nitrat or muriat of barytes, and from the known constituents of this salt to find the quantity of sulphur, whilst the charcoal here remains perfectly untouched. See Aikin's Dict. Vol. I.

We now proceed to treat briefly of the several ingredients; and first of

NITRE.

Nitre, or common saltpetre, is formed by the union of the nitric acid with potash. This salt is of a fresh taste, and its crystals are, uniformly, six-sided prisms, terminating in dihedral pyramids, or cut off with a slope, and channelled, frequently, from one end to the other. There is great abundance of this salt in nature, as it is continually forming in places frequented by animals, and on walls secured from rain, and in the rubbish and plaster of old buildings.

Three circumstances seem to be necessary to the formation of nitre. First calcareous earth, which forms a nidus for its reception in buildings, &c.: Secondly, animal substances: for it is a known fact, that places watered by animal liquors, and in a state of a putrefaction, such as dunghills, stables, &c. afford great quantities of nitre: Thirdly, the contact of air, without which no nitre could be formed. Upon the above principles are founded the beds of artificial nitre-works. To this effect a number of proposals have been made, from time to time, by ingenious men, whereby vast quantities of nitre might certainly be formed, to the great advantage of the state, and emolument of the speculator. But this has been little attended to in England, which is supplied from her settlements in the East-Indies, with more than perhaps she can consume. Spain alone could furnish all Europe with this commodity, according to the information of Mr. Townsend; but she keeps it principally for her own use, and that of her colonies. France also manufactures this

 article

article in great abundance, of as excellent and pure a quality as any on the globe. When nitre has been dissolved, and freed of its impurities, and re-crystallized, it is fitted for the making of gunpowder.

OF SULPHUR, OR BRIMSTONE.

Sulphur, or brimstone, is a combustible body; dry, brittle, of a citron yellow colour, without smell, except when burnt; of a peculiar taste, which is weak though perceptible. It is electric when rubbed, and crackles and breaks instantly on being exposed to heat. Sulphur is combined with a number of substances, and pervades all nature; but we shall here only speak of it pure and uncombined. It is usually obtained by the decomposition of a mineral substance termed *pyrites*. In Saxony and Bohemia, it is manufactured in a more elaborate manner than elsewhere; it is put in earthern tubes, in small pieces, and placed on an oblong furnace. One end of the tube stands in the furnace, and the other passes into a vessel of cast-iron, containing water. In this receiver the sulphur accumulates, though impure; and it is afterwards purified by melting it in an iron ladle, which causes the impurities to be precipitated to the bottom. It is again kept in fusion in a copper boiler, and then poured into wooden cylindrical moulds, which give it the form in which we usually see it in commerce.

CHARCOAL.

Charcoal is the black residue of vegetable matter, whose volatile principles have been decomposed and set at liberty by fire. Different vegetable matters afford coal in greater or less abundance, according to the solidity and form of their texture. It has a strong attraction for all substances which contain *vital* or *pure* air, (now termed *oxygen*) which is one reason for the phenomena we see in the explosion of gunpowder. The charcoal of willow-wood is preferred,

preferred, by many, for the manufacture of gunpowder; though others maintain, that the coal of hard woods is equally fitted for the purpose, provided it be thoroughly burned, and preserved from the contact of the atmosphere during the operation. The wood before charring is cleared of its bark.

Having now mentioned, in a cursory way, the nature of gunpowder, and its several parts, it remains only that we detail a few other ingredients, and processes, employed in the composition of fire-works, previously to describing the fire-works themselves.

How to break or granulate Sulphur.

Take some spirits; put a handful of sulphur therein, and let it dissolve; then take a broad stick, and stir it about till it grows mealy, and like sand. If you would again have it strong and hard, throw a little nitre into it.

To combine Oil with Sulphur.

Fill a matrass with fine pulverised sulphur, about one-third full; on this pour as much nut or elder oil as will fill the matrass half full; set it in warm ashes, and let it stand for eight or nine hours, and the oil will change the sulphur to a high red colour.

To make artificial Camphor, and its Oil.

Take of pulverised juniper-gum two pounds, and of distilled vinegar enough to cover it; close them together in a glass phial; set it for twenty days in warm horse-dung; then take it out again, and pour it out into another glass, with a wide mouth to it; expose it to the sun for a month, and you will have a concreted camphor, which is in some measure like the natural camphor: this, for use in fire-works, is pulverised by grinding with sulphur in a mortar. The best

best artists recommend the use of the natural camphor in preference to the artificial.

The oil of camphor is made by adding a little oil of sweet almonds to the camphor, and working it in a brass mortar with a pestle; which will turn it into a green oil. Those works that have camphor in their composition should be kept from the air to prevent evaporation.

To make Moulds for Rockets.

Rockets bearing the pre-eminence, and being the principal things belonging to fire-works, it is requisite to give some account of every part of them—how they are made, finished, and fired. In order to do this, I shall first endeavour to give the curious some idea concerning the moulds they are formed in; these are turned commonly of close and hard wood, as of white plumb-tree, box, chesnut, cypress, juniper, Indian wood, &c. Some also are made of ivory; and for rockets of an extraordinary large size, they are cast in brass or copper, and turned in the inside in a nice manner: the foot, or basis, with its cylinder, wart, or half-bullet, may in these, as in others, remain of solid wood. The whole is commonly turned of the size and form of a column in architecture; and embellished with ornaments, according to the taste of the fire-worker.

The size of the cylinder is agreed, by the most famous artificers, to be, for rockets from a half to six pounds, six diameters; but for the larger size, four, four and a half, or five diameters of the height of the orifice.

The rockets which go under the denomination of small ones, are those whose inward diameter cannot receive a ball that exceeds one pound. The middling sort are those whose diameter can admit balls of one, two, or three pounds; and great ones are such, whose bore will receive balls from three to a hundred pounds.

Rocket

Rocket moulds, from a few ounces to three pounds, are ordinarily seven diameters of their bore long; the foot, two or three diameters thick; the wart, two-thirds of the diameters; and the piercer, one-third of the bore; the roller, two-thirds, and always one or two diameters, from the handle, longer than the mould; the rammer, one diameter shorter than the mould, and somewhat thinner than the roller, to prevent the sacking of the paper when the charge is rammed in; having, always, one still shorter, that, when the shell of the rocket is rammed half full, you may use that with more ease. For the better illustration, see Plate I. fig. 1. which represents the mould with its basis, cylinder, bore, and piercer. A B the interior diameter of the mould:—C D the height of the mould, seven diameters: from D to E is the height of the breech at bottom, which stops the mould when the rocket is driving; and this is one and one-third diameter. Upon this bottom you have a solid cylinder, whose height is one diameter of the orifice A B; this cylinder is crowned with a wart, or half bullet I, having a hole in the centre, in which is fixed the iron, or copper piercer F.—G is a pin that keeps the bottom and cylinder together. 2. The roller. 3. The rammer. 4. The shorter rammer.

It is to be observed, that some of these moulds are made nine diameters of their orifice long; the shell therefore, with the wart, will be twelve diameters. These sort of rockets fly very high, because of their length, containing a greater charge than the short; nevertheless, the piercer needs to be no longer than seven diameters, but substantial, so as to keep in its proper attitude:—it will require the dimension of two-thirds of the diameter at bottom, and from thence, tapering, to half the diameter.

To

To prepare Cases for Swarmers, or Rockets.

THE cases, or trunks, of rockets, are made of different sorts of things, viz. paper, wood, tin, pasteboard, linen, leather, &c.

In paper cases, which are for the most part made use of, it must be observed, 1. That great care ought to be taken in winding, or rolling them, upon the roller, tight and close. 2. That the concave stroke be struck clean, smooth, and without large wrinkles: and, 3. That each sort of cases be of an equal length and size.

The rocket-shells being very tiresome for two persons to make by hand, a machine has been invented for the easement. It is made of an oaken board, about two foot wide, and three or four inches thick, planed smooth, and cut out into channels, or grooves, of different sizes, to serve for greater, or lesser, rockets; and is commonly called the saddle. To these sort of saddles are also made pressers, whereby the cases on the roller are pressed down with a heavy hand; the handle of the roller having a hole in the middle, a small iron bar is put in, and as the man presses with one hand, he turns the roller with the other; and, by this means, the paper is brought as tight as it ought to be. See fig. 5 and 6.

For four and six pound shells it is to be observed, that each sheet of paper (except the first and last, in the part where the neck is formed) be a little moistened.

The necks of rockets may be formed several ways:—for those of three quarters of a pound, a well twisted pack-thread will do, which, having one end tied to a stick and put between one's legs, and the other to a post, will draw it close with ease. The large shells require more strength; one end of a strong cord being fastened to a post, and the other to a leathern belt, with a hook, as fig. 7:—and this, by main force, draws the cord, twisted about the neck of the case,—as you see in fig. 8.

Some

Some make use of a bench, on one end of which is fixed a post, to which a cord is fastened, and conveyed over a pulley, and through a hole in the bench, to a treddle, to which it is fastened, whereby the necks are forced very tight. See fig. 9.

The necks of extraordinary large sized rockets are forced, with strong cords, over screws, and round-necked irons, proportioned to the size of the shell. See fig. 10.

The wooden, tin, and paste-board rockets, are supplied with necks, turned of wood, joined, and fastened through the sides of the shell with wooden pegs.

Preliminary Observations in preparing the Charges for Rockets; and to order their Fires of various Colours.

BEFORE you begin to charge the shell of the rocket, be very careful that the powder is well worked and cleaned; that the nitre is thoroughly refined, and made into an impalpable powder; that the sulphur be well cleansed, and brought to the highest perfection; that the coals be of lime-tree, or other soft wood, well burnt, powdered, dried, and sifted; and that all these ingredients be well mixed together and searced through a fine sieve.

When you are satisfied in these things, and have weighed the proportionable quantities of each, put the mixture into the work-board, fig. 11. and grind it with the grinder, fig. 12. for an hour: then try your charge, by sifting a little on a table, and if, when lighted, it burns away in an even fire, and does not fly up, it is a sign that it is worked enough; but if at one place it burns quicker than another, or stops its course, then you must grind it more. The charge being thus prepared, you must put it up safe in a place that is neither too hot, cold, nor damp, in a box, or other dry vessel; and when you charge your rocket, then sprinkle and mix the charge with a little brandy.

Having rammed a rocket, for trial, fire it in a secure open place; if it mounts even and high, and gives a report as soon

as it turns, it is a sign of being made to perfection; but if the rocket burst as soon as it is lighted, then the charge is too fierce; or if it rises a little, and falls back, then the charge is foul and weak:—the former is rectified by adding more charcoal; and the latter, by some meal-powder. For the rest, it must be observed, that the larger the rockets are, the weaker must be the charge; and on the contrary, the smaller they are, the stronger must be their charge.

If you would represent a fiery rain falling from the rocket, mix among your charge a composition of powdered glass, filings of iron, and saw-dust; this shower is commonly called the peacock's tail, on account of the various colours that appear in it.

You may also exhibit a variety of colours issuing forth from a rocket, by mixing among the charge a certain quantity of camphor, which produces a white, or pale fire; rosin, a red and copper colour; blood-stone, which has been nealed and beaten to a palpable powder, a blood red; sulphur, a blue; sal ammoniac, a green; antimony, a reddish, or honey colour; ivory shavings, a shining silver; filed agate-stone, an orange; and pitch, a dark and deep coloured fire. This must be managed with discretion; and practice will be the best teacher in that particular, for long lessons are more fit to perplex a young beginner than put him forwards.

The charges are commonly divided into three sorts, or degrees, viz. white, grey, and black. I have, the better to guide beginners in this art, set down several sorts of charges, according to the proportion of rockets, but without distinguishing the three several colours; wherefore you have to observe, that to the grey charges are four ingredients, viz. mealed gunpowder *, nitre, sulphur, and charcoal; to the white charges three ingredients, viz. nitre, sulphur, and charcoal; and to the black charges two ingredients, viz. mealed gunpowder and charcoal.

* Wherever the term *mealed powder*, or *powder* only, is used, it means *finely bruised gunpowder*: *corn powder* is whole gunpowder.

Charges

Charges for Land Swarmers, or Small Rockets.

Mealed gunpowder one pound, and charcoal one ounce. *Or,*

Mealed powder five ounces, and charcoal half an ounce.

Mealed powder fifteen ounces, and charcoal two ounces.

Mealed powder six ounces, nitre four ounces, sulphur one ounce, charcoal one ounce and three quarters. This last may be used for the fuzee of others.

Charges for Water Rockets.

Nitre, or saltpetre, two ounces, sulphur half an ounce, and charcoal one ounce and a half.

Mealed powder one pound and a half, nitre four pounds, sulphur two pounds, and charcoal five ounces.

Mealed powder four ounces, nitre one pound, sulphur eight ounces, and charcoal one ounce.

Nitre two ounces, sulphur half an ounce, and charcoal half an ounce.

A general Charge for Rockets of two or three Ounces.

Mealed powder twelve ounces, nitre two ounces, sulphur half an ounce, charcoal one ounce and a half.

Charges for Rockets of four, five, and six Ounces.

Powder, *i.e.* gunpowder, fifteen ounces, nitre twelve ounces, sulphur one ounce and a half, and charcoal four ounces.

Powder one pound and a half, nitre one pound and a half, sulphur ten ounces and a half, and charcoal twelve ounces.

Powder two pounds, nitre one pound, sulphur three ounces, and charcoal fourteen ounces and a half.

Powder eight pounds, nitre twelve pounds, sulphur two pounds, and charcoal four pounds.

Powder twelve ounces, nitre two ounces, sulphur two ounces, and charcoal two ounces.

Nitre four pounds, sulphur fourteen ounces, and charcoal one pound.

Powder three ounces, nitre half an ounce, sulphur half an ounce, and charcoal half an ounce.

Powder one pound and a half, charcoal three ounces and three quarters.

For eight, nine, and twelve Ounce Rockets.

Mealed powder eighteen pounds, nitre eight pounds, sulphur one pound, and charcoal four pounds.

Powder four pounds, nitre three pounds and a half, sulphur fifteen ounces, charcoal one pound four ounces.

Powder three pounds, nitre two pounds, sulphur two pounds, and charcoal one pound.

Powder three pounds, nitre two pounds, sulphur one ounce, and charcoal one pound.

Powder nine pounds, charcoal one pound eight ounces.

Nitre two pounds four ounces, sulphur eight ounces, charcoal fourteen ounces, and antimony four ounces.

Nitre one pound two ounces, sulphur two ounces, and charcoal four ounces.

Nitre ten ounces and a half, sulphur one ounce, charcoal three ounces, and brass file-dust half an ounce.

Nitre two pounds four ounces, sulphur eight ounces, and charcoal fourteen ounces.

For one, and one and a half Pound Rockets.

Mealed powder three pounds, nitre four ounces, sulphur one ounce, and charcoal four ounces and a half.

Powder thirty-two pounds, sulphur two pounds, and charcoal six pounds.

Powder

Powder two pounds, nitre two pounds and a half, sulphur twelve ounces, and charcoal one pound three ounces.

Powder six pounds and a half, charcoal one pound.

Powder three pounds, nitre fifteen ounces, sulphur four ounces, and charcoal seven ounces and a half.

Powder four pounds, nitre one pound eight ounces, sulphur ten ounces, and charcoal one pound twelve ounces.

Powder two pounds, nitre one pound four ounces, sulphur one ounce, and charcoal eight ounces and a half.

For two and three Pound Rockets.

Mealed powder three pounds eight ounces, nitre three pounds ten ounces, sulphur one pound four ounces, and charcoal one pound three ounces.

Nitre four pounds eight ounces, sulphur one pound eight ounces, and charcoal one pound four ounces.

Nitre sixty pounds, sulphur two pounds, and charcoal fifteen pounds.

Powder two pounds thirteen ounces, nitre fifteen ounces, sulphur four ounces, and charcoal seven ounces and a half.

Powder twelve ounces, nitre one pound eight ounces, sulphur six ounces, and charcoal six ounces.

Powder four pounds, nitre nine ounces, sulphur three ounces and a half, and charcoal ten ounces and a half.

Powder one pound, nitre eight ounces, sulphur two ounces, and charcoal three ounces.

Powder eleven pounds, and charcoal two pounds ten ounces.

Nitre six pounds four ounces, sulphur one pound, and charcoal two pounds and a half.

For four or five Pound Rockets.

Mealed powder six pounds, nitre four pounds, sulphur one pound and a half, and charcoal two pounds six ounces. *Or,*

Nitre

Nitre sixty-four pounds, sulphur eight pounds, and charcoal eight pounds.

For six, eight, or nine Pounders.

Mealed powder twelve pounds three quarters, nitre six pounds, sulphur two pounds and a half, and charcoal five pounds and a half. *Or,*

Nitre thirty-five pounds, sulphur five pounds, charcoal ten pounds.

Mealed powder twenty-two pounds and a half, and charcoal five pounds twelve ounces.

Mealed powder one pound, nitre half a pound, sulphur two ounces, and charcoal three ounces.

Nitre nine pounds, sulphur one pound nine ounces, and charcoal three pounds and a half.

For ten and twelve Pounders.

Nitre sixty-two pounds, sulphur nine pounds, charcoal twenty pounds.

Powder eleven pounds, nitre seven pounds, sulphur three pounds, and charcoal six pounds.

For fourteen, fifteen, and sixteen Pounders.

Powder ten pounds and a half, sulphur nine pounds three quarters, and charcoal seven pounds.

Nitre twenty-three pounds, sulphur eight pounds, and charcoal sixteen pounds.

For eighteen or twenty Pounders.

Powder twenty-two pounds, nitre sixteen pounds, sulphur seven pounds, charcoal thirteen pounds and a half.

Nitre twenty-four pounds, sulphur twelve pounds, and charcoal twenty-six pounds.

For

For thirty, forty, and fifty Pounders.

POWDER eight pounds, nitre sixteen pounds, sulphur two pounds, and charcoal four pounds.

Nitre thirty pounds, sulphur seven pounds, and charcoal eighteen pounds.

For sixty, eighty, and a hundred Pounders.

NITRE thirty-six pounds, sulphur ten pounds, and charcoal eighteen pounds.

Nitre fifty pounds, sulphur twenty pounds, and charcoal thirty pounds.

To bore the Rockets, or ram them over the Piercer.

SINCE the boring of rockets is one of the principal things belonging to them, (for their operating well) the bores are to be made in proportion to the size of the rockets; some of them are bored tapering to a point; others are hollowed square, running also to a point; and others are rammed over a round piercer, which is fixed in the wart of the rocket-mould. See fig. 1. I, which stands perpendicular, running tapering to a point. The stronger the charge of the rockets, the narrower should be the bore; and the weaker the charge, the deeper and wider:—for if a strong charge is bored too deep, it will break in ascending; and if it is bored too little, and the charge too slow, it will fall to the ground without any effect:—they are commonly, in middling charges, bored two-thirds of the tube from the neck.

The boring must be performed strait and even; and although some will give themselves the trouble to bore them by hand, it is better, when a quantity is to be bored, to send them to a turner.

The rockets should be bored but a few days before they are to be used; and kept in *dry places;* which you must also observe in other materials for fire-works.

For garnishing of Rockets.

THIS is done several ways, for they may be both within and without furnished with crackers. On the outside it is done in the following manner, viz. That end of the rocket which is solid is divided into three equal parts, and then bored in the middle of each, quite to the charge; at the bottom of these holes paste a ring of thin paper, upon which fling some mealed powder; then fix in the crackers, stuffing the sides with some tow or flax; and over that, paste a covering of paper, to close the opening between the rocket and crackers.

The inside is finished thus: put a small round board (in which you have bored several holes) upon the charge; then strew mealed powder in them, and fix your crackers; cover it with a cap, and paste it to the outside of the rocket.

You may also furnish rockets, both within and without, with sparks, stars, and fire-rain, when those materials are joined either within or without. You may also fix to the large rockets, swarmers, by boring a touch-hole in both, filling them with mealed powder, and, after the touch-holes are fixed exactly on one another, glue them together with a bandage of paper; thus you may mark a winding figure with a thread on a rocket, and place your swarmers accordingly. See fig. 13. You may also, instead of swarmers, place a globe on the top of the rocket, charged with the composition of rockets, and filled with crackers; this globe must have a touch-hole, and be lighted before the rocket is let off, and it will have a good effect. Several other things may be done that way, as the genius of every virtuoso will direct him. See fig. 14, 15.

How

How to proportion the Rocket-Poles and Sticks.

It is common to tie but one rocket to a stick; but six or seven may be placed round the thick end, which must be worked with grooves, as you see fig. 17. But as no rocket would ascend high, if it were not for the true balance observed in the pole or stick, you must further observe, that these sticks are made of light, dry, and strait wood, and must (to one and two pound rockets) be seven times as long as the rocket; which proportion, of the small ones of seven diameters, must also be observed in the larger end. That end to which the rocket is tied, must be two-fifths; and below, one sixth of the diameter. It is best to give the turner an unbored rocket, and one that is bored, thereby not only to measure the length, but also balance the weight. After the rocket is tied to the stick, take it four inches from the neck of that rocket which is not yet bored; and from the neck of the bored one, about two or three fingers, so as to stand on the back of a knife, or one's finger, in an equilibrium. In large rockets, the poles must be eight or nine rockets long; and to find their balance, you take their libration twelve inches from the neck.

Rockets without Sticks.

There are rockets made without sticks. Fix to the small ones (from four, to eight, nine, or ten ounces after they are bored and rammed) four wings, in the nature of arrow-feathers, made either of light wood or paste-board, and glued crossways to the rocket: their length must be two-thirds; and the breadth, below, one-sixth of the length of the rocket; the thickness may be one-eighth of the diameter of the mouth. See fig. 18 and 19. These sort of rockets are fired on a board or stand, placed between four small sticks; as you see in fig. 20.

 Others

Others fasten one end of a wire, which is about a foot long, twisted like a screw, to the mouth of the rocket, and hang an iron ball to the other end, of an equal weight with the rocket. See fig. 21.

Of Girandel Chests; how, and with what, the Rockets are fired therein.

THE girandel chest, see fig. 16, is made of wood, of what size you think proper, according to the number of rockets you design to fire at once.

The method of firing the rockets is performed several ways; some fill the necks of them with mealed powder; others, with quick match; wherewith, or with gun match, they fire them: the best way to light the girandel, or other fire-works, is with a match, prepared on purpose in the following manner:

Cut some slips of paper, of the length of half a sheet, and about one or two inches wide; roll, and glue, each of them together over a little round and smooth stick, of a quarter of an inch thick; this done, take it off, when dry, and fill it with the composition hereafter-mentioned; ramming it in, by little and little, with a less stick than that upon which you rolled the shell. These sort of matches are put upon pinchers, as you see in fig. 22; and when they are lighted, they cannot be extinguished either by rain or wind.

Their Composition.

MEALED powder three ounces and a half, nitre seven ounces, and sulphur three ounces three quarters, moistened with linseed oil.

Mealed powder one pound, nitre one pound, and sulphur thirteen ounces, moistened with linseed oil.

Mealed powder one pound, nitre one pound four ounces, sulphur four ounces, charcoal two ounces, resin two ounces

and a half, moistened with turpentine and linseed oil, and worked well together.

Mealed powder twelve ounces, nitre two ounces, sulphur three ounces and a half, charcoal an ounce and a quarter, turpentine one ounce, and tallow three ounces and a quarter; first melt the turpentine and tallow together, then stir the other ingredients among it, and pour it in the paper shells; when dry, they are fit for use.

Of Rockets that run upon Lines, or Ropes, from one place to another.

THESE are made several different ways; and to give them the more shew, some garnish them with figures of various devices.

The first sort is contrived by fixing two iron rings, or a wooden tube, to a rocket, filled with a certain quantity of a suitable composition, and bored as usual; through these rings, or tubes, is put a line, on which the rocket is to run; this is of the most simple kind, for being arrived at the place where the duration of its combustible matter will allow it to reach, it there stops. This sort is represented in fig. 23.

For the second sort, fill any rocket, whose orifice is equal to that of the former, but much longer, to the height of four diameters; bore it to the depth of three and a half. Upon this composition put a cap, or little wooden partition, without any hole through it; glue this to the inside of the rocket, or secure it any other way, to prevent the fire, when arrived at that place, from catching hold of the composition contained in the other part of the case. This done, charge the remainder of the rocket to the same height as before, viz. to four diameters (three and a half must be bored); after this choak the rocket at top, and make a little receptacle for the priming, as at the other end; or else, fit a round piece of wood to it, with

with a hole through the middle, as you see in A, fig. 24. which you cover with a little cap; to this add, on one side, a tube made of very thin iron plate, which fill with mealed powder; then bore a hole through the side of the rocket, near the other side of the partition that is in the middle, and fill it with mealed powder; this is done to convey the fire through the tube to the receptacle A, where it lights the other rocket, and consequently obliges it to return back to the place whence it came; the upper part which holds the priming must be covered with paper, as well as the small tube that conveys the fire from that to the other end. This rocket must also have two iron rings, or a wooden tube, to run along the line. You may make the diversion the greater, by tying small paper crackers all round. The contrivance of this rocket is very pretty. You have the representation in fig. 24, 25.

The decorations and devices that are usually fixed to these running rockets, may be either flying dragons, pigeons, Mercuries, Cupids, or any other, as fancy or the occasion of a feast or rejoicing requires.

Charges for the Line Rockets.

Mealed powder three ounces, nitre one ounce and a half, and charcoal three ounces, will be a right proportion for three, four, or six ounce rockets.

Mealed powder eight ounces, nitre two ounces, sulphur half an ounce, and charcoal one ounce.

Mealed powder nine ounces, nitre one ounce, sulphur three quarters of an ounce, and charcoal four ounces.

Mealed powder fourteen ounces, nitre seven ounces, sulphur two ounces, and charcoal four ounces.

These charges may be used for sixteen and twenty-four pounders.

Mealed powder one pound, nitre half a pound, sulphur three ounces, and charcoal five ounces. This charge is proper for three quarters and one pound line rockets.

It

It will be adviseable to make some trials of the charges, that you may be sure of not failing in the performance: see fig. 23, 24, 25, where *a* is the rocket; *b* the tube, or, instead thereof, some rings that slide upon the cord; *c* the partition; *d* the pipe, for the communication of the fire from one rocket to another.

How to join two Rockets to one another; the one to burn in the Water, and the other suddenly to fly up into the Air.

TAKE two rocket shells of equal dimensions; fill one with a good charge, quite full; the other charge, bore and tie to a stick, as usual; the former you glue, upside down, to the middle of the latter; and, towards the end, tie it round with a cord, which is somewhat longer than the rocket stick; to the end thereof fasten a ring, and, in that, a leaden ball, which is to keep both rockets in a due position on the surface of the water; through this ring put the end of the stick, which is provided with a cross that is somewhat wider than the diameter of the ring, and keeps the cord, ring and ball under water: the communication of the fire must be made below the rockets, by a small pipe, filled with mealed powder very secure, so as to keep it from the water; for, as soon as the water rocket is burnt to the end, the fire will make its way through the pipe, and the land rocket will disengage itself by its force from the case of the other, and leave the cord, ring and ball, behind in the water: see fig. 26.

How to make Water-rockets, Water-brands, Water-cats, Water-ducks, &c. that turn themselves in the Water.

THE cases for the water-brands, and also their sticks, must be made something longer than ordinary, and be filled with a composition of coarse coal-dust, small rubbed tanner's-

bark,

bark, or saw-dust, but in the same method as sky-rockets. The whole case is to be nine or ten diameters long, and must be divided into five equal parts, and be charged two-fifths full of composition: upon this, charge a report of a quarter high, and upon that, fine iron flakes, in order to sink it; then cover it with paper, and draw it together with a cord;—the charge is lifted up a little in the neck, and supplied with brandy-dough, or mealed powder moistened with brandy, and glued over with paper; and having fixed a wooden swimmer below the neck, it is dipped in wax and pitch, and is ready for use.

Water-crackers, which turn in the water, are thus prepared:

This case is made nine or ten diameters long; the neck is drawn quite close, and charged with mealed powder almost half full: upon this, a partition is made with a hole in it; then put corned powder for a report; upon that is placed another partition; the rest is filled with mealed powder, and the end tied close, and the paper cut short at both ends; when these crackers are to be fired, make a touch-hole at the end of both, reversed, and having filled them up with mealed powder, and covered them well with brandy-dough, you may fire and fling them into the water, having before dipt them in melted wax, or pitch.

It is to be observed, that, to the water cat-cases, we may proceed thus (from one ounce to half-pound crackers); but, if larger, they are too heavy, and will not so soon turn up again in the water, till some parts of them are consumed; wherefore, to remedy this, put in the case, first, three measures of charge; upon this, put a little corned powder, then again, two measures of charge, and a little corned powder, and proceed thus as far as the report; upon the charge is placed a partition of wood, with a hole in it; on that, a report of good corned powder; then tie it close: further, open it a little, putting some mealed powder to it mixed with brandy; and when you would use it, anoint it all over with grease or

linseed

Fire-Works


Fig 1
A
B
C
D
E
G
2
3
4
Fig 5.
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
37
a
b
c
d
A

linseed oil. The water-crackers, or divers, are commonly rammed in one, one and a half, and two ounce, cases, stratified in the manner just mentioned, taking two measures for each lay of water cat-charge, and a little corned powder between each.

There are other sorts of rockets, that may be represented swimming on the water: these are made in the same manner as the one, or one ounce and a half rockets, bored one-third in the charge, then put into a paper cylinder with two small wooden heads, or bases, having a hole bored to the centre of each: the height of this cylinder must be equal to half of the rocket, and the hole through the centre of each head fitted exactly to the rocket; when you have fixed every thing to a nicety, put it into melted wax, or pitch; and when cold, you may fire and fling it into the water. See fig. 27, 28, 29.

You may also put these sorts of rockets into a paper cone, and fasten it to the neck of the rocket; or else in a bladder full of wind, which, instead of dipping in melted wax, do over with a mixture of four parts of linseed oil, two parts of bole armenic, one part of white lead, and half a part of ashes. See fig. 30, 31.

You may mix along with the reports of the rockets, certain sparks and stars, intermixed with meal and corned powder; to this is fixed an iron or wooden tube; from each end of this goes another smaller tube, all having communication with one another. These are filled with mealed powder, covered over with paper, dipped in wax or pitch, and a counterpoise being fixed below, it is fired. As soon as the composition is burnt down to the cap, it is conveyed through small tubes to the lower part, where beating out the partition, it disperses the powder, stars, &c. into the air. See fig. 32.

Charges for Water-Rockets.

MEALED powder six ounces, resin one ounce, charcoal three quarters of an ounce, nitre one ounce, corn powder one ounce.

Nitre one pound, sulphur eight ounces, mealed powder eight ounces, and charcoal four ounces and a half.

Nitre four ounces, sulphur three ounces, and charcoal three quarters of an ounce.

Mealed powder one pound and a half, nitre half pound, sulphur four ounces and a half, charcoal six ounces, coarse coal two ounces and a half, and lead, for sinking, one ounce.

Mealed powder two pounds, nitre one pound, sulphur ten ounces, charcoal eight ounces, coarse coal three ounces, sinking lead one ounce and three quarters (for three quarter ounce rockets.)

Mealed powder two pounds, nitre two pounds, sulphur one pound, charcoal four ounces, coarse coal three ounces, tanner's-dust two ounces and a half, saw-dust two ounces, glass powder one ounce, sinking lead one ounce and three quarters, for one pound rockets.

Mealed powder half a pound, nitre three quarters of a pound, charcoal five ounces, saw-dust half an ounce, and a quarter of an ounce of fine chopped cotton, boiled in nitre lye.

Charges for Water-crackers.

MEALED powder two pounds and a half, nitre one pound and a half, sulphur ten ounces, charcoal eleven ounces, coarse coals nine ounces; the sinking is, to two ounce crackers, a quarter of an ounce of lead.

Mealed powder two pounds and a half, nitre two pounds and a half, sulphur one pound five ounces, saw-dust twelve ounces,

ounces, charcoal three quarters of a pound, coarse coals half a pound; the sinking, a quarter of an ounce.

Mealed powder four ounces, nitre five pounds, sulphur two pounds and three quarters, tanner's-dust one pound and a half, charcoal one pound, coarse coals two pounds and three quarters, glass-dust four ounces, lead three quarters of an ounce to sink it.

Charges for Tumbling Water-crackers.

Mealed powder one pound, nitre one ounce, and charcoal one ounce and a half.

Mealed powder one pound, nitre eight ounces, sulphur three quarters of an ounce, and charcoal one ounce and three quarters.

Mealed powder three quarters of a pound, charcoal four ounces; for one and a half, or two pound rockets.

Charges for Water-cats.

Mealed powder two parts, nitre four parts, sulphur one part, coarse coals two parts, saw-dust two parts, and antimony three parts, moistened with linseed oil.

Mealed powder two ounces and a half, nitre three ounces and a half, sulphur two ounces and a half, and antimony half an ounce.

Mealed flour one pound, nitre two pounds, sulphur one pound, and charcoal one pound.

Nitre fifteen ounces, sulphur five ounces, saw-dust eight ounces, and antimony two ounces.

Some general Remarks upon Rockets.

1. Your rockets must have their proportionable height, according to the diameters of their orifices.

2. Their

2. Their necks must be drawn, or choaked, firm; and, to prevent the cord giving way, they must be glued over.

3. Prepare your composition just before you want it.

4. Let it be neither too damp nor too dry, but sprinkle it over with a little oily substance, or a little brandy.

5. When you drive your rockets, put always equal quantities of composition in your cases at a time.

6. Carry with your mallet an even and perpendicular stroke, when you charge your rockets.

7. The cavity must be bored upright and perpendicular, exactly in the middle of the composition.

8. Bore your rockets just before you use them; then handle them carefully, lest their form should be spoiled.

9. Let the sticks and rods be well proportioned, strait and smooth.

10. Put your rockets, when completed, in a place that is neither very damp nor dry.

11. Let most of your rockets have at top a conic figure, by that means they will the easier shoot through the air.

12. Avoid, if possible, a damp, foggy, rainy or windy night, to play your rockets.

Defective Rockets are chiefly discovered by the following Observations.

1. When they are fired, and in mounting two or three perches, they break and disperse, without performing their proper effects.

2. When they remain suspended on the nail, and waste away slowly, without rising at all.

3. When they form an arch in their ascent, or a semicircle, and return to the ground before their composition is burnt out.

4. When they mount in a winding posture, without an uniform motion.

5. When they move on slowly and heavy.

6. When

6. When the cases remain on the nails, and the composition rises and disperses in the air.

More of these vexatious accidents will sometimes frustrate the hopes of a young practitioner; but as the above are the principal ones, he must endeavour to avoid them in his first beginning.

Of Rocket-flyers, and the Manner of charging them.

THESE are of two sorts, namely, the single and double; the latter are made after the following manner:

Have a nave, or button turned, the dimension of three inches, together with two knots upon it, perpendicular, one against the other, of an inch and a half long, and so thick that both rocket-cases may fit over them; (there must be a hole, of the third of an inch in the centre of the nave, for the iron pin to go through, on which it is to fly;) after this, take two rocket-cases, of equal dimensions, which are choaked quite close at the neck, and glued: ram in the charge, so far as to leave only room to fix them on the two knobs upon the nave: this done, bore into both rockets, near the closed-up necks, small touch-holes, (and one more near the pin) in that which is to burn first; from this hole, carry a little pipe to the hole near the neck of the other rocket, having first filled it with mealed powder, that when the rocket is almost burnt out, the second may be lighted by the first. The three touch-holes are to stand in one row; and you may on the other side fix a couple of reports, which will cause a swifter motion.

The single flyers are made with more ease; the neck in these must not be tied close, as in the former, but they must be fired in that place; these do not turn so well as those that are made double.

Of Fire-wheels.

Of these there are three sorts, viz. single, double, and triple; some of their fells are of a circular form, others an hexagonal, octagonal, or decagonal form; some like a star, without fells; some, and the most of them, are made to run perpendicular to the earth; others horizontal; all may be ordered so as to serve either on land or water.

Horizontal wheels are often fired two at a time, and made to keep time like vertical wheels; only they are made without any slow or dead fire: ten or twelve inches will be enough for the diameter of wheels with six spokes. Fig. 34. Pl. 11. represents such a wheel on fire, with the first case burning.

The fire-wheels that are used on land, turn upon an iron pin or bolt, drawn or screwed into a post. The nave is turned of close and firm wood, in which the joiners glue the spokes, according to the number of the fells, which must be carefully joined together; then have a groove hollowed round, so deep that the rocket or case may be about half lodged therein. See fig. 35.

The double wheels must have their fells turned stronger and wider, with a groove for the rockets, not only at top, but also on one side thereof; plying the necks of the rockets at top, to the right, and those of the sides to the left hand. See fig. 36.

Your rockets being ready, and cut behind a little shelving, bore them; the first, three diameters of its orifice; the second, two and three quarters; the third, two and a quarter; the fourth, two diameters; the fifth, one and three quarters; the sixth, one and a half; the seventh, one and a quarter; the eighth, one diameter; always the latter something shorter than the preceding:—after this, they are primed with mealed powder worked up with brandy,

brandy, and when dry, glued in the above described grooves; you must bear the first fired rocket's neck above the rest, underlaying it with a tin plate, or any thing else; the same you must observe in the head of the last fired one, wherein you put the charge of a report; you may also glue on every end of the rockets, a report of paper, with small pipes of copper, or goose-quills, which are fixed one end in the side of the rocket, and the other in the report. When all is dry, then you may cover your wheel on one or both sides, with linen or paper, in what form you would have it.

Of Tourbillons.

Having filled some cases within about one and a half diameter, drive in some clay; then pinch their ends close, and drive them down with a mallet; when done, find the centre of gravity of each case, where nail and tie a stick, which should be half an inch broad at the middle, and a little narrower at the ends: these sticks must have their ends turned upwards, so that the cases may turn horizontally on their centres: at the opposite side of the cases, at each end, bore a hole close to the clay with a gimlet; from these holes draw a line round the case, and at the under part of the case bore a hole, with the same gimlet, within half a diameter of each line towards the centre; then from one hole to the other draw a right line: divide this line into three equal parts, and at X and Y, fig. 38. bore a hole, and from this hole to the other two, lead a quick match, over which paste a thin paper.

A fire wheel which is to whirl horizontally in the water must be thus ordered:

Take a pretty large wooden dish, or bowl, that has a broad flat rim; (see fig. 39;) also a smooth dry board, something larger than the dish, and formed into an octagon; in the middle of this board make a round hole that will hold

a water-

a water-ball, so that one half be received in the dish, and the other half rise above the surface of the board; nail this board upon the rim of the dish, and fix the ball in the middle, tying it fast with wire; then glue your rockets in the grooves which are made round the edges of the board, laying them close to one another, so that successively taking fire from one another, they may keep the wheel in an equal rotation. You may add, if you please, on each side of the wheel, a few boxes, filled with crackers or cartouches, erected perpendicular; and also fix double and single crackers, following in a range, one after another, for two or three fires; or as many as the extent of the wheel will admit.

For your private fusees, observe that you conduct one from the rocket, which is to be fixed to the composition of the ball, in a channel.

Fill these channels with mealed powder, and cover them close with paper: also lay a train of fusees of communication from the rockets to a cartouch, and from that to the rest. See fig. 40.

Lastly, when all is ready and covered, dip the whole machine into melted pitch, and secure it from the injury of the water; the ball is fired first, and, when lighted, you place it gently on the surface of the water, and then fire the rocket.

To try a fire-wheel; first weigh one of the rockets, and tie it to a fell, with cord, and according to the weight, fill little long bags full of sand, tying them likewise on the rest of the fells; then, hang the wheel on an iron pin, and fire the rocket, and if it turns the wheel, then you may assure yourself it will be complete.

Wheels formed like stars, are to have their spokes fixed upright in the nave, like other wheels, only with grooves on one of the sides of each, where you glue the rockets; at the bottom of each rocket is made a little hole, whence the fire is conveyed through little pipes, filled with mealed powder

powder up to the next, and so on, all round; then cover it with linen cloth, or paper, in the shape of a star, and place it on the iron axis.

Observe, that all the rockets used in fire-wheels have their necks tied close, leaving only a small conveyance from one rocket to another:—the last of all must be well secured below, where you may place a strong report of corn powder.

Charges for Fire-flyers and Wheels, of four, five, and six Ounce Rockets.

MEALED powder three pounds, nitre two pounds, charcoal five ounces, and sea-coal three ounces.

Mealed powder fourteen ounces, nitre six ounces, charcoal three ounces and a half, sulphur three ounces, and sea-coal three ounces.

Mealed powder fifteen ounces, nitre six ounces, sulphur three ounces, and charcoal three ounces.

Nitre five pounds, sulphur three quarters of a pound, charcoal one pound four ounces.

These charges are bored with a round bodkin.

Mealed powder two pounds, sea-coal eight ounces, and charcoal ten ounces.

Mealed powder three pounds, sulphur eight ounces, and charcoal ten ounces.

These charges may be used for triple wheels, and must be bored, one-third, with a bodkin.

For Wheels of one Pound Rockets.

MEALED powder six pounds, nitre three pounds, sulphur one pound seven ounces, charcoal two pounds nine ounces, and tanner's-dust one ounce.

The bore must be an inch and a half.

For Wheels of one and a half, and two Pound Rockets.

MEALED powder six pounds, nitre three pounds and a half, sulphur one pound and a half, charcoal two pounds three quarters, and saw-dust one ounce and a half.

The first rocket in the wheel is, in length, two diameters and a half of its orifice.

For Wheels of three and four Pound Rockets.

MEALED powder nine pounds, nitre one pound and a half, sulphur one pound two ounces, and charcoal three pounds four ounces.

The first rocket is bored but one and a half of its diameter.

TO MAKE SINGLE AND DOUBLE CARTOUCHES, OR BOXES, TUBES, STARS, SPARKS, &c.

WHEN some hundred boxes or cartouches are adjusted and fixed in machines of great fire-works, they afford among the towering rockets great delight to the spectators. These boxes are made either of wood, paste-board, or copper; and are charged and proportioned according to their strength. If made of wood, they must fit exactly, and receive each other, so as to seem but one continued piece; and if paste-board, you must glue on a foot at bottom, of a hand high, to each of them: the inside of these machines must exactly fit and correspond with the outside of the cartouches themselves, and be so contrived as to slip into one another.

The

The engine, fig. 41, is very proper for the construction of those boxes, and represents the bench: the other, fig. 42, shews the cylinders, upon which, (having greased them first over with soap) you fashion your boxes, just as you think proper, by pasting one thickness of paper upon another, and fixing a handle to the end of the cylinder.

Having formed them, put them to dry in a moderate heat; too great a heat will shrivel them up; when dry, take one after another off the cylinder, and immediately clap round wooden bottoms (the edges being first done over with glue) into them, and sprig them on the outside, to make them secure.

The single boxes are to be changed in the following manner:

1. Put in some corn powder.

2. Upon that charge, fix a round paste-board, well fitted to the concave side of the box, which has five or six small holes, and is on both sides laid over with mealed powder tempered with brandy.

3. Put upon the paste-board a little mealed powder, and upon that well pierced crackers, so as to stand with their necks downwards: the principal rocket is put in the middle, with the neck downwards, open at both ends; so that being lighted above, and burning down, it may fire the rest of the crackers, which are blown up in the air by the corn powder.

4. The empty spaces between the large fire-case and the crackers, are carefully filled up, and the cartouch is stuffed at top with tow, or else with saw-dust boiled in nitre lye.

5. The cartouch is covered with a cap, which is glued very closely thereon; and for the great case reaching out of the cartouch, make in the middle of the cap a hole, through which it is put, and close the opening by glueing some slips of paper round it. The fire-case is loose, covered with a paste-board cap.

Double Boxes, or Cartouches.

In fig. 43, is exhibited the construction of a case, called a double one; to enlarge on the description thereof seems to be needless, only observe, that the bottoms of the upper boxes serve for the covers of the lower, a hole being made, through which the composition of the lower box is fired, after the upper rocket has forced away the empty box, which already has discharged its load. The upper box you cover, as has been shewn above. If there are more than two cartouches upon one another, they are called Burning Tubes, which, when fired, shorten by degrees, the cartouches following one another till all are fired; some are intermixed with artificial globes, and several other fancies, which afford great pleasure to the spectators.

These boxes, or cartouches, are placed in long cases made for that purpose. The vacancies about the cartouches may be filled up with sand. See fig. 44.

Another Sort of Fire Tubes.

These are made of solid, hard, and dry wood, of what height and thickness you think proper. Bore the middle of the wood one-third, or a quarter of its diameter, after which divide the whole height into equal parts, each exactly corresponding with the sky-rockets you design to fix upon them, but rather a small matter shorter: all these divisions are cut sloping downwards, except the uppermost, which must run out in a cylinder. On the rims of each of these divisions make a groove all round, of about a finger's breadth; in these grooves bore small holes, by which the fire may be conveyed through pipes from the cavity of the tube, to light the rockets that stand behind the paper cartouches, which must be made secure to the wood, lest they should fly up along with the rockets.

The

The construction of the hollow tube in this and other such-like tubes is expressed in fig. 45. A, the fire-stars and sparks, interspersed with corn powder. B, a box filled with paper or crackers. C, a fire-ball, or water-globe, which you please. D, another box filled with crackers. The hollows between these fires are filled up with corn powder, to blow up the globes and boxes one after another.

The stars and sparks made use of on this occasion are prepared in the following manner:

Take of beaten nitre five pounds and a half, mealed powder two pounds four ounces, and sulphur one pound twelve ounces.

Mealed powder three pounds, nitre six pounds, sulphur one pound, camphor half an ounce, tanner's-bark two ounces, or else saw-dust; all finely sifted and moistened with linseed oil.

Mealed powder one pound, nitre four pounds, sulphur half a pound, and pounded glass six ounces, moistened with linseed oil.

Nitre half a pound, sulphur two ounces, antimony one ounce, and mealed powder three ounces.

Nitre half a pound, sulphur three ounces, antimony one ounce, and iron file-dust half an ounce.

Nitre two pounds, mealed powder ten pounds, and sulphur one pound.

Nitre one pound, sulphur half a pound, mealed powder three ounces, and antimony one ounce.

Nitre one pound, sulphur two ounces, powder of yellow amber one ounce, crude antimony one ounce, mealed powder three ounces.

Sulphur two ounces and a half, nitre six ounces, fine mealed powder five ounces; frankincense in drops, mastich, corrosive-sublimate, of each four ounces; white amber and camphor, of each one ounce; antimony and orpiment, of each half an ounce.

These

These ingredients being well beaten, and finely sifted, must be sprinkled over with a little blue or gum-water, and formed into little balls, of the bigness of a small nut, then dried in the sun, or near a fire, and laid up in a dry place, to be ready, on occasion, for playing off with fire-works. When you use them, wrap them up in tow.

The following Stars are of a more yellow Cast, inclining to white.

Take four ounces of gum-tragacanth, or gum-arabic, pounded and sifted through a fine sieve, camphor dissolved in brandy two ounces, nitre one pound, sulphur half a pound, coarse powder of glass four ounces, white amber one ounce and a half, orpiment two ounces; incorporate them and make balls of them, as directed before.

Sparks are prepared thus.

Take nitre one ounce, melted nitre half an ounce, mealed powder half an ounce, and camphor two ounces; having melted these things by themselves (only when you use them) in an earthen pot, pour on them water of gum tragacanth, or brandy that has gum arabic, or gum tragacanth dissolved in it, that the whole may have the consistence of a pretty thick liquid; this done, take one ounce of lint, which before has been boiled in brandy, vinegar, or nitre; when dry, throw it into the composition, and mix and stir it about, till it has soaked it up; then roll them up in pills, about the size of great pins-heads, and set them to dry, having first sprinkled them with mealed powder.

Some of these pyramidical tubes and fire-works, are now and then fired in large rooms, upon grand entertainments, in miniature, wherein are employed odoriferous pills, and other ingredients, that have a fragrant smell; these pills are commonly

commonly composed of *storax calamita*, gum-benzoin, gum-juniper, of each two ounces; *olibanum*, mastich, frankincense, white amber, yellow amber, and camphor, of each one ounce; nitre three ounces; lime-tree-coal four ounces; beat these ingredients very fine; pulverise and incorporate them together, and moisten with rose-water wherein you have dissolved some gum arabic or gum tragacanth; you may form them into pills, and dry them in the sun, or before a fire.

Single Tubes, or Cases.

These are only filled with compositions, and to the outside are fastened some crackers, serpents, or cartouches; these cases being generally round and uniform, like a cylinder, you are to trace out a winding line from the top to the bottom, on which cut holes to the depth of two or three inches. See fig. 46. Into these holes contrive to fix paper-cases with wooden bottoms, wherein you may put any sort of rockets you please; but take care you provide little holes, to lead from the great tube to the corn powder under these rockets.

Another fire tube is delineated, fig. 47. This is surrounded with cartouches, disposed in a serpentine order, like the first, which are glued and nailed as secure as possible; out of these are dispersed great numbers of squibs. As for the rest, they have nothing but what is common in others.

Another Fire Tube.

The circumference of a cylinder is, by a cord, divided into a certain number of equal parts, and being brought into a polygonal figure, cutting away the convex part, it is brought into angles.

Bore the plain sides with a number of holes, perpendicularly, so as to penetrate obliquely to the great boring in the

the middle: into these holes thrust crackers, squibs, or serpents.—See fig. 48.

Fig. 49 exhibits a tube, whose length is six diameters of its thickness. The cylinder being divided round the rim into six parts, and each of those into seven parts, reserve one of them for the list, between each of which make channels, which being six in number, place little mortars of the same dimensions therein.

The mortars must be turned of wood; bore the bottoms, and add a chamber to them; each chamber must be one-third, or one-half, of the depth of the fluting; and the breadth, one-sixth only. These chambers are designed to hold corn-powder.

Secure the mortars on the outside with strong paper cases, and nail them fast in the hollow channels, whose cavity they are to fit exactly; their length may be double to their breadth:—each mortar must contain a globe made of paper, with a wooden bottom; and their chambers must be charged with corn-powder.

These mortars fix in a spiral line, one only in each fluting, with iron stays, and bind the middle with an iron plate, fastened on each side of the interstices; but before you fix the mortars, you must not forget to piece little holes in the tube, and to fix the touch-holes of your mortars exactly upon them, priming both with mealed-powder. Every thing relating to this may be plainly conceived in the figure, where A and B describe the mortars, and C the globe or cartouch.

Of Salvo's.

THESE, in fire-works, are a great number of strong iron reports, fixed either in a post or plank, and, with a fire, discharged at once.

Charges

Charges for Cartouches, or Boxes.

MEALED powder six ounces, nitre one pound eight ounces, sulphur four ounces, and charcoal four ounces and a half.

Mealed powder fourteen ounces, nitre five ounces, sulphur two ounces, and charcoal three ounces.

Mealed powder one pound, nitre three quarters of a pound, sulphur four ounces and a half, tanner's-bark or saw-dust two ounces, and charcoal four ounces.

Charges for Fire Tubes.

MEALED powder six pounds, nitre four pounds, charcoal two pounds, resin half a pound, tanner's-bark five ounces, moistened with a little linseed oil.

Mealed powder three quarters of a pound, nitre four pounds, sulphur ten ounces, and saw-dust four ounces. This charge may be used dry.

Mealed powder five pounds, nitre three pounds, charcoal one pound six ounces, resin three quarters of a pound; not moistened.

A Preservative for Wood against Fire.

THIS being a necessary article in the execution of fire-works, it will not be improper to set it down in this place.

Take brick-dust, ashes, iron-filings, pulverized, of each an equal quantity; put them together in a pot; pour glue-water or size upon them; then put them near the fire, and, when warm, stir them together. With this size, wash over your wood-work; and when dry, repeat it, and it will be proof against fire.

The Manner of preparing, and making Letters and Names in Fire-Works.

Burning letters may be represented after several methods.

Order a joiner to cut any capital letters, of what length and breadth you please, or about two feet long, and three or four inches wide, and an inch and a half thick, fig. 50. —hollow out of the body of the letters a groove, a quarter of an inch deep, reserving for the edges of the letters a quarter, or half, an inch of wood. If you design to have the letters burn of a blue fire, then make wicks of cotton or flax, according to the bigness and depth of the grooves in the letters, and draw them leisurely through melted sulphur, and place them in the grooves; brush them over with brandy, and strew mealed powder on; and, again, with brandy and thinly dissolved gum-tragacanth, and on that strew mealed powder also; when dry, drive small tacks all round the edges of the grooves, and twist small wire to those tacks, that it may cross the letters, and keep the cotton or flax close therein; then lay over it brandy paste; strew, over that, mealed powder; and, at last, glue over it a single paper.

If you would have the letters burn white, dissolve six pounds of nitre, and add to it a little corn-powder; in that dip your wicks of cotton or flax. You may, instead, use dry touchwood, cut into pieces of an inch thick; put them in melted nitre over a fire; let them lay till the nitre is quite soaked through the wood; after which, mix powdered nitre with good strong brandy; take some cotton, and with a spatula, or your hands, work that, the nitre and brandy, together; then squeeze it out; strew the cotton over with powdered nitre, and make wicks; having first placed the touchwood in the grooves, lay the wicks over that and the vacancies about it, and then proceed to make it tight and secure, as has been directed above.

There

There is another method of burning letters, without grooves, and this is done by boring small holes in the letters, about an inch distance one from the other; the diameter of the holes must not be above the eighth of an inch; into them put, and glue, cases, rammed with burning charges:—these letters do not burn so long as the others, except the charges are very long.

Another method for burning of letters is, when they are formed, by a smith, of coarse wire, about a quarter of an inch thick; when this is done, get some cotton spun into match-thread, but not much twisted; to two yards of this, take one pound of sulphur, six ounces of nitre, and two ounces of antimony; melt these ingredients in a kettle, first the sulphur by itself, and then the rest all together; when melted, put in the match-thread and stir it about, till it has drawn in all the matter; then take it out, and strew it over with mealed powder; let it dry, and wind it about the white letters: fasten these upon a board, that has been well laid over with a preservative to keep it from firing. When you have lighted one letter, all the rest will take fire immediately.

Letters cut through a smooth board, which is made to slide in the grooves of a chest, are ordered thus: the lid of the box is made full of holes, for dispersing the smoke of the lamps, or wax tapers, which are set behind to illuminate the letters; behind the cut-out letters is pasted oil paper, of various colours, which, when the lamps are lighted, has a fine effect. By these means, various changes may be made in representing devices, names, coats of arms, &c. But this way is more practised on the stage, in plays, than in fire-works.

Charges for burning Letters with Cases.

MEALED powder six ounces, nitre one pound, mixed with rock-oil, or petroleum oil.

Mealed

Mealed powder three quarters of a pound, nitre nine ounces, and sulphur three ounces, mixed up dry.

Mealed powder five ounces, nitre seven ounces, sulphur three ounces, and file-dust half an ounce; moistened with linseed oil.

To order and preserve Leading-fires, Trains, and Quick-matches.

FIRE-WORKS being of various kinds and inventions, it is impossible to assign certain rules for their several performances. But to say something of what concerns a master's praise, it is observed, that great fire-works are not to be fired above once or twice at most; for it would not be deemed an artful performance to fire one cartouch after another; likewise, the match pipes, the most preferable of which are either iron, lead, or wood, and should be strengthened or closely twisted round with the sinews of beasts, and filled with slow charges, which ought to be well tried; or else furnished with match-thread, dry and well prepared, and afterwards either joined to the grooves made in the boards, or only laid free from one work to another. The joinings of the pipes must be well closed and luted with potter's clay, so as to prevent the fire from breaking out; these pipes must also have little vent holes to give the fire air, or else it would be stifled, and burst the pipes; but these holes must be so contrived, that the flame may vent itself in the open air, and at some distance from the works, so as to prevent touching them.

All burning matches are to be as distant from the machines as possible, to prevent accidents.

A particular direction for conducting your trains and fusees, cannot be given, because of the variety of postures, situations, and contrivances of machinery: those rules already given will be sufficient for the ingenious: add to this, the advantage a novice in this art may gather from the direction

direction in the figures, which, with much care and industry, have been traced out for their information.

Charges for Fusees, or Leading-matches.

MEALED powder three ounces and a half, nitre four ounces, sulphur one ounce and three quarters, and charcoal one ounce and three quarters.

Mealed powder three ounces, nitre nine ounces, sulphur four ounces and a half, and charcoal half an ounce.

Mealed powder four ounces, charcoal half an ounce; and coarse coal half an ounce.

Mealed powder half a part, nitre three parts, sulphur two parts, and charcoal one part; this last is very slow.

Of Water-balls.

BALLS, in fire-works, are made of different fashions; some are globular, some oval, some conical, some cylindrical, others in the form of a pendant, or drop.

The water-balls are commonly made of knitted cord-bags, or of wood; those made of bags are shaped like ostriches eggs, and are,

1. Filled with their proper charge.
2. The outside is dipped in glue, and wound about with hemp or flax, till it is a quarter of an inch thick with it.
3. This ball is then coated over with cloth, and about the touch-hole is glued over with a piece of leather.
4. The touch-hole is bored with a gimlet, and stopped with a wooden peg.
5. At the bottom of the globe, pierce a small hole through to the composition, in which fasten a small copper-pipe, furnished with a paper report, together with a leaden balance; glue the report fast to the ball; then dip the ball in melted pitch; open the touch-hole, and prime it with a quick-burning charge.

These

These balls keep a long time under water before they rise; and if a true balance is not observed in the lead, or the ball is overcharged, they will sink to the bottom, and burn out; therefore you must well observe, that when a water-ball, without the balance, is two pounds weight, you must give it four, or four ounces and a half of lead; but, if it weighs one pound and a half, balance it with three, or three ounces and a half.

Water-balls, or globes, made of wood, which swim and burn upon the water without any further effect, are of two sorts, viz. single and double; the single ones are made thus: get a hollow globe, turned somewhat oblong, with a vent-hole; fill that with a good and approved charge, but not too close; prime the end with some mealed powder; then glue a stopple in the hole, which must be thrice as thick as the shell of the globe, in which beforehand the counterpoise is cast of lead; when dry, make a hole at top, large enough for a two-ounce cracker to enter; through this, ram down the charge in the globe, and fill it quite full with the same composition; then glue it over with a paste-board: and, lastly, fix a small copper pipe through the stopple, having bored a hole through it for that purpose; to the pipe fasten a paper report; when this is done, dip the whole in pitch: these are called single water-globes. Both sorts of globes are, for better security, twisted and tied round with several rows of strong packthread.

Double water-globes are such, which after one is fired, discharges another. These have chambers at bottom, which are filled with gunpowder; on these put a cover of thick leather, which has several holes in the middle, and goes close to the side; on this strew mealed powder, and place thereon a fire-globe, which is charged. Fig. 52, will demonstrate the construction. Observe,

1. That the little chamber, at bottom, ought to be one-fifth of the breadth of the whole globe, and that its height be one and a half.

2. That

2. That the water-ball B should be encompassed with a water-ball composition, as you see by H.

3. The partition C is for this purpose, that when the powder in it shall have the fire conveyed to it through the pipes F E G, it may with more force blow up the ball in the body of the first; this taking fire at the hole D, will burn upon the water for some time, and then, to the astonishment of the spectators, on a sudden, it will blow up the ball that was in it.

4. You must be very careful to secure the piece of leather or board that covers the little chamber, lest it should be blown up by the composition of the greater globe, before it is all burned out.

How to charge a Water-globe with many Crackers.

TAKE, for this purpose, a single water-globe, which may be round, or of an oval form, and fill the same with the composition hereafter-mentioned. Hollow the outside, in several places, to the size of your reports, or crackers, which are to be fixed in them: to each of the crackers belongs a small copper tube, filled with mealed powder, which is to be fitted to the small holes in the flutings, in the manner as expressed in the print, where fig. 53. A, are the flutings; B, the little holes for the fuzes; C, the upper orifice for priming; D, the hollow stopple, through which the ball is primed; E, the form of the crackers, which are to be fixed in the flutings; F, little fusees belonging to them.

How to prepare a Water-mortar, or Water-pump, with several Tubes.

TAKE seven wooden tubes; wrap them about with cloth that is either pitched or dipped in glue, twisting them round very tight with packthread. Their height, thick-

 ness,

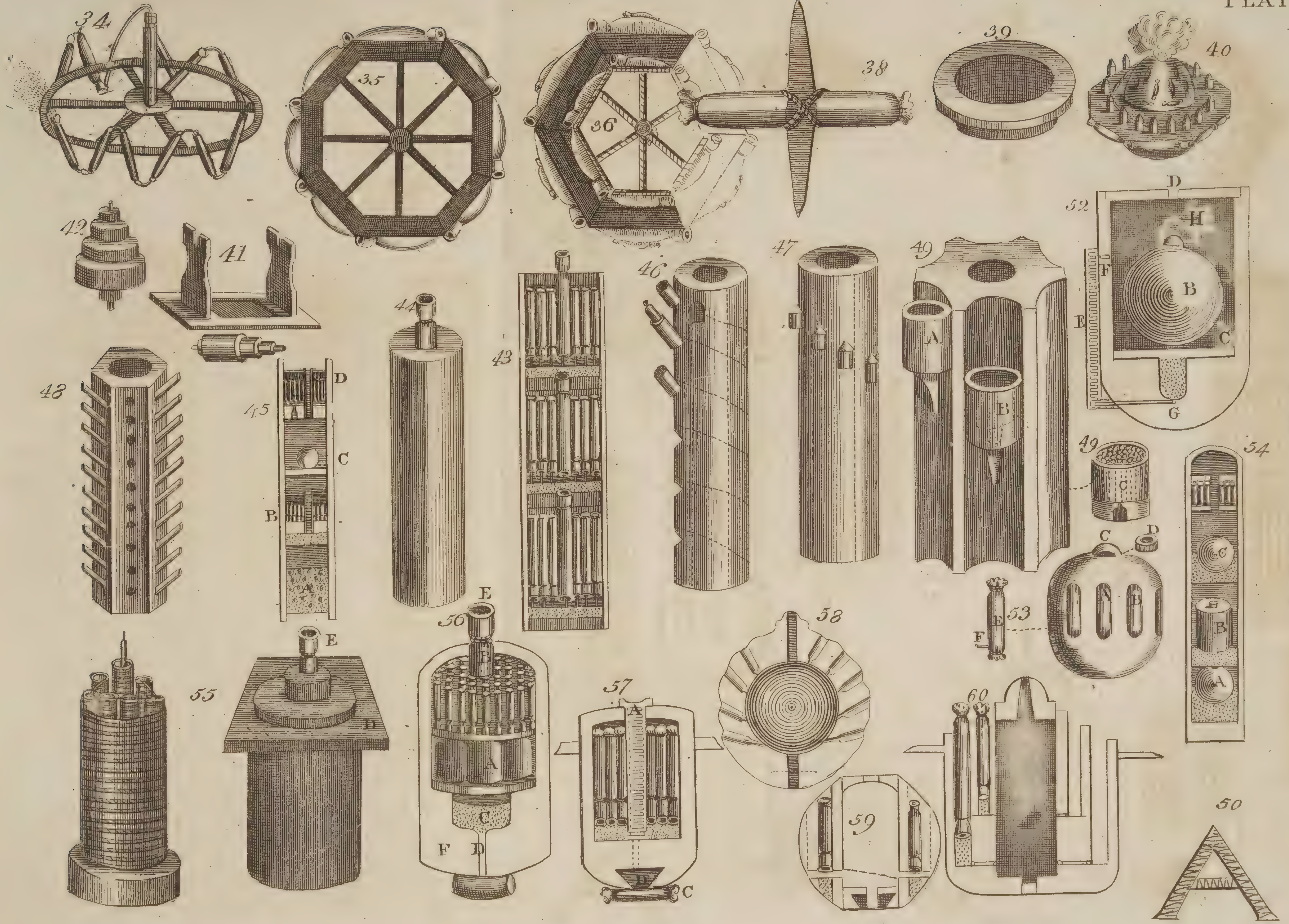
ness, and diameter, you may order as you think proper, only allowing the middlemost a greater height than the rest; bind them together in one cylindrical body: to the bottom fix a round board, with nails, and then with strong glue stop up all the crevices to prevent the air getting to the composition: this done, fill the tubes according to the order represented in fig. 54. First pour into each tube a little corn-powder, about half an inch high; upon that put a water-ball A; upon that a slow composition; then again corn-powder; upon which put a water-globe, filled with squibs, as you see in B; on that again a slow composition; then corn-powder; and then a light ball, as may be seen in C; over this put, a third time, a slow composition upon corn-powder, as before, which you must cover with a wooden cap; on this fix running rockets, not too close, but to leave room enough between for a wooden case filled with a water composition; the remainder of the tube fill with a slow charge, and close it up. Your tubes being all filled in this manner, get a square, or round, piece of plank, with a round hole in the middle, large enough to receive the ends of all the tubes, which cover close, to preserve the powder and composition from being wet; this float-board is marked with the letter D, fig. 55. Thus prepared, dip it in a quantity of tar, or melted pitch; then put the rocket E, or a small wooden tube filled with a strong composition that will burn on the water, into the orifice of the middle tube; the composition of which should be more slow than the rest.

If you would have the tubes take fire all round at once, you must pierce the sides of the great one with small holes, corresponding with those in each of the other tubes; by this means the fire may be conveyed to all of them at once, and consume them equally and at one time; but, if you would have them burn one after another, you must close them well up with pasteboard; and to each tube fix a fusee of communication, filled with mealed powder, or a

slow

Fire-Works.

PLATE. 2.



slow composition, through which the fire may be conveyed from the bottom of that which is consumed, to the orifice of that next to it; and so on, successively, to such as have not been fired.

How to charge a large Water-globe with several little ones, and with Crackers.

GET a wooden cylinder made; let its orifice be at least one foot diameter, and its height one and a half: let there be a lodge, or chamber, at bottom, to hold the powder, which must be confined by a tampion, or stopple, joined to a round board, fitted exactly to the inside of the globe; through the middle of the stopple must pass an iron tube filled with mealed powder; then prepare six water-balls, or more, if you think fit, so that when all are set together in the circumference of the globe, they may fill up that circle; each of these balls must be provided with an iron fusee in its orifice, filled with mealed powder. Having charged the chamber of the globe with corn-powder, let down the forementioned board, with the stopple upon it; then arrange the six water-balls; cover them with another round board, that has six little round holes, corresponding with the six iron fusees of the balls, which must a little surmount it. Spread this last board over with mealed and corn-powder, mixed together, and upon it place as many rockets as the globe can hold: in the midst of these fix a large rocket, into whose orifice the iron tube may enter, which is the same you see in E, fig. 56.

This tube must have holes drilled all round the plane of the said partition or board, that the fire having a communication through them, may reach the running rockets, and at the same time fire the water-balls, whose tubes rise out of the board; and thence, after having penetrated down to the chamber below, may blow up the whole into the air, and make a great noise. See the figure, where A points

out the six water-balls; B, the great rocket in the middle of the running ones; C, the chamber for the powder; D, a communication, or the iron pipe, to convey the fire to the paper cracker; F, the globe; which having been adjusted after the manner directed, cover it close round, and dip it in tar, to preserve it from the water.

To prepare the Water Bee-hive, or Bee-swarm, both single and double.

THE single bee-swarm is thus prepared. Have an oblong globe turned, whose length is two diameters of its breadth, or proportioned to the height of your rounding rockets, which place round the wooden tube marked with A; this must be of an equal height with the globe, and be filled with a composition of three parts of powder, two of nitre, and one of sulphur; at the lower end of the globe fix a paper cracker C. The letter D is a counterpoise of lead, through which you convey a little pipe, or fusee, to communicate with the charge in the wooden tube: at top, fix a round board for a balance, and two little holes, which convey the fire to the charge for blowing up the rockets. See fig. 57.

How to prepare a Water-globe, on the Outside, with Running Rockets.

GET a wooden globe perfectly round and hollow, bore on the outside several cavities, sufficient to receive running-rockets, leaving a quarter of an inch between the extremities of them, and the composition within the ball; then bore the wood left between each, with a small gimlet; fill them with mealed powder; then put in your rockets; close the top of the globe with a wooden cylinder, that has a hollow top, with a touch-hole to receive the priming; the bottom stop with a stopple, which likewise has a con-

conveyance to the cracker that is commonly fixed beneath it; between which and the stopple fix also a leaden counterpoise, to keep the whole upright in the water. See fig. 58.

To prepare Water-globes with single or double ascending Rockets.

For the first sort, have a globe turned with a tube in the middle, half its diameter wide, leaving two inches for the placing of solid wood at the bottom; round this tube, bore holes for small rockets; after which, burn, with a red hot wire, or small iron, touch-holes out of the large tubes into the little ones; then fill the globe with the following composition, *viz.*

Two pounds of nitre, eight ounces of sulphur, eight ounces of mealed powder, twelve ounces of saw-dust; this done, close the top with a stopple which has a touch-hole in the middle; then put a good deal of mealed powder into the small tubes, up to the touch-holes; and after you have placed your rockets upon that, fill the vacancy round with a little corn-powder; glue over them paper-caps; then dip the globe into pitch, but not over the paper covering; fix a counterpoise at bottom; and when the fire has burned half way, or further, in the large tube, it will communicate through the touch-holes, and discharge all the rockets at once.

The second sort are made after the same manner, only the middle tube is not bored so wide, because of giving more room for two rows of small tubes round it; the first row, next to the tube, is bored a little below the middle; the second almost near to the end; the touch-holes for the former are burnt from the inside of the great tube, and those of the latter, from the outside hole, are closed again with a wooden pin: in the large tube you may lodge a strong re-

port of iron, charged with corn-powder, having a touch-hole left at top. See fig. 59, 60.

Charges for single Water-globes.

Corn-powder half a pound, nitre sixteen pounds, sulphur four pounds, ivory shavings four ounces, saw-dust boiled in saltpetre-lye, four pounds.

Mealed powder one pound, nitre six pounds, sulphur three pounds, iron filings two pounds, and resin half a pound.

Mealed powder four pounds, nitre twenty-four pounds, sulphur twelve pounds, saw-dust eight pounds, powdered glass half a pound, and camphor half a pound.

Corn-powder one ounce, nitre twelve ounces, sulphur four ounces, and saw-dust three ounces.

Nitre twelve ounces, sulphur four ounces, saw-dust two ounces, melted stuff three quarters; this must be rammed in tight.

Mealed powder one pound four ounces, nitre one pound eight ounces, sulphur nine ounces, saw-dust five ounces, pounded glass one ounce, melted stuff four ounces; mix them together with a little linseed oil.

Mealed powder eight ounces, nitre five pounds, sulphur two pounds, copper filings eight ounces and a half, and coarse coal-dust eight ounces and a half.

Nitre eight ounces, sulphur three ounces, saw-dust one ounce, and tanner's-bark two ounces.

Nitre six pounds twelve ounces, sulphur two pounds fourteen ounces, melted stuff half a pound, saw-dust one pound, coarse coal-dust one pound, and pounded glass one pound, mixed up and moistened with vinegar.

Nitre two pounds twelve ounces, sulphur two pounds six ounces, melted stuff four ounces, saw-dust eight ounces, charcoal one ounce and a half, and pounded glass three quarters

quarters of an ounce, moistened with linseed oil, and mixed up with a little corn-powder.

Charges for double Water-globes.

NITRE four pound six ounces, sulphur one pound four ounces, saw-dust half a pound, and coarse coal-dust six ounces, moistened with a little vinegar or linseed oil.

Mealed powder one pound four ounces, sulphur four ounces, and charcoal two ounces, moistened with *Petroleum* oil, or rock oil.

Nitre three pounds, sulphur a quarter of a pound, and saw-dust boiled with nitre ten ounces, moistened a little.

Charges for Bee-swarms.

MEALED powder thirteen ounces and a half, nitre six ounces, sulphur two ounces and a half, fine charcoal three ounces, coarse charcoal one ounce, and fine saw-dust three ounces.

Mealed powder three quarters of a pound, nitre six ounces, sulphur three ounces and a half, fine charcoal four ounces, and coarse charcoal two ounces and a half.

Mealed powder four parts, nitre eight parts, sulphur two parts, coarse charcoal two parts, and fine charcoal one part.

Odoriferous, or perfumed Water-Balls.

HAVE balls turned, about the size of large walnuts; fill them with any of the compositions specified below; after they are filled and ready, light and put them into water. This is generally done in a large room, or hall, at grand entertainments.

The

The Compositions for them are as follows:

Nitre four ounces; *storax calamita*, one ounce; frankincense, one ounce; mastich, one ounce; amber half an ounce; civet, half an ounce; saw-dust of juniper, two ounces; saw-dust of cypress, two ounces; and oil of spike, one ounce.

Nitre two ounces, flowers of sulphur one ounce, camphor half an ounce, raspings of yellow amber half an ounce, coal of lime-tree wood one ounce, flowers of benjamin half an ounce; let those which are to be powdered be done very fine; then mix them together, as usual.

Nitre two ounces, myrrh four ounces, frankincense three ounces, amber three ounces, mastich one ounce, camphor half an ounce, resin one ounce, boiled saw-dust one ounce, lime-tree coal half an ounce, bees-wax half an ounce; mix them up with a little oil of juniper.

Nitre one ounce, myrrh four ounces, frankincense two ounces and a half, amber two ounces, mother of pearl four ounces, melted stuff half an ounce, and resin half an ounce; mix them up with oil of roses.

Mealed powder three ounces, nitre twelve ounces, frankincense one ounce, myrrh half an ounce, and charcoal three ounces, mixed with oil of spike.

The Manner of preparing the melted Stuff.

Melt twenty-four pounds of sulphur in a shallow earthen pan, over a clear fire, and as it melts, fling in sixteen pounds of nitre; stir them well together with an iron spatula; as soon as they are melted, take it off the fire, and add to it eight pounds of corn-powder; mix it well together, and, being cooled, pour out this composition upon a polished marble, or metal-plates, and then divide it into pieces about the size of a walnut. This composition is chiefly used in

in military fire-works, and not for those I am treating of; but for those fire-works which are only for pleasure, it is distinguished by warm and cold melted stuff, and is prepared in the following manner.

Take for the first sort half a pound of nitre; grind among it three quarters of an ounce of antimony, till one cannot be distinguished from the other; then melt one pound and a half of sulphur, put the mixed nitre and antimony to it, and mix them well together; this done, put it warm into a wooden mould of two pieces, which should be well greased on the inside: this stuff you break afterwards into less pieces: it is, on account of its clear fire, used to imitate stars.

The Manner of preparing the cold melted Stuff.

GRIND the above ingredients, or eight ounces of mealed powder, four ounces of nitre, three ounces of sulphur, and one ounce of coal-dust, together, till all is of one colour; this done, moisten that stuff with the white of eggs, gum-water, or size, and make a stiff dough; then strew, on a smooth board, some mealed powder; roll the dough upon that a quarter of an inch thick; strew, again, mealed powder upon it; then cut it in square pieces, and let them dry; or else form small balls of it, of the size of a small nut, or larger; then roll them in mealed powder, and put them up to dry.

To prepare a Globe which burns like a Star, and leaps about both on Land and Water.

CAUSE a globe to be turned, of dry wood, whose diameter is the length of a half pound or a pound rocket: divide this globe into two equal parts; in the middle of one of the half globes, on the inside, make a cavity, deep, long, and wide enough to hold three or four rockets, or crackers,

crackers, so that the other half of the globe may be easily and closely fitted upon them; after this take three crackers, one with strong reports, and two without any; place them so into the hollow, that the head of the one may lay to the other's neck, and be so ordered that as soon as the one is spent, the other may take fire and force the globe back, and thus alternately from one to the other till it comes to the report, which finishes. Care must be taken that the fire passes not from the first to the next cracker, before it has quite consumed the first; but as I have given a caution in the article about rockets that run on a cord, the same may be observed here.

Having taken care to fix the rockets, cover them with the other half globe, and join them firmly with strong pasted paper.

To charge Globes, which leap on Land, with Iron and Paper Crackers.

Take a hollow wooden globe, which has a touch-hole at the top, in the form of a small cylinder; fill it with an aquatic composition, quite full; then bore into the charge five or six holes, about half an inch wide, in which put iron petards, or crackers, which run tapering; provide them at the lower end with a small touch-hole, and cover the top with a tin-plate, in which there is four holes, which you must close up with wads of paper or tow, after you have filled them with the best corn powder: and when you fire them on even ground, you will see them leap as often as a cracker goes off. See fig. 61, plate III.

The other sort is not much unlike the first, except that to this you add a certain number of crackers, which are disposed as you may observe in fig. 62: A the crackers, B the touch-hole.

How

How the Globes, discharged out of a Mortar, are made and ordered.

FIRST find the mouth of a mortar, and divide it into twelve parts; then have a globe turned of wood, which is two diameters of the mortar's mouth high; divide the diameter in six equal parts, and let the height between A and C be the diameter of the globe; the thickness of the wood H I, should be one-twelfth of the above diameter, and the thickness of the cover of the globe; the height of the priming chamber F shall be one-sixth and a half of the diameter, but its breadth only one-sixth; the diameter of the touch-hole B is one-fourth, or one-sixth, of that of the chamber: for the better understanding these directions, see fig. 63.

The manner of filling these globes is thus:

Take hollow canes, or common reeds; cut them into lengths, to fit the cavity of the globe, and fill them with a weak composition made of three parts mealed powder, two of coal, and one of sulphur, moistened with a little linseed oil (excepting the lower ends of them, which rest upon the bottom of the globe, which must have mealed powder only, moistened likewise with the same oil, or sprinkled over with brandy, and dried:) the bottom of the globe cover with mealed powder, mixed with an equal quantity of corn powder; the reed being filled in this manner, set as many of them upright in the cavity of the globe, as it will contain; then cover it well at top; and wrap it up with a cloth dipped in glue; the priming must be of the same composition with the reeds.

The globes represented at 64 and 65, are contrived like the above, only the first of these is filled with running rockets, and the last with crackers, stars, and sparks, interspersed with mealed powder, and put promiscuously over the crackers. The figures are so plain, as to require no further explanation.

No.

No. 66 is the representation of a globe, which plainly shews its construction: the great globe, which contains the lesser, is the same as described above; for it is charged with running rockets. In the midst of these rockets fix a globe in a cylindrical form, with a flat bottom, and a chamber and touch-hole. The cavity of this inner globe is filled with iron crackers, and covered with a flat covering: the priming chamber is to be filled with the same composition as has been directed for the above globes: the fusees must be filled with good mealed powder.

To prepare the Light Balls, proper to be used at Bonfires.

TAKE two pounds of crude-antimony, four pounds of sulphur, four pounds of resin, four pounds of coal, and half a pound of pitch; having powdered all these ingredients, put them into a kettle, or glazed earthen pan, over a coal fire, and let them melt; throw as much hemp, or flax, into it as may be sufficient to soak it up; then take it off the fire, and whilst it is cooling, form it into balls.

You may wrap them up in tow, and put them either into rockets or globes.

To prepare the Paste for Stars and Sparks.

TAKE five ounces and a half of mealed powder, one pound twelve ounces of sulphur. *Or,*

Take three pounds of mealed powder, six pounds of nitre, one pound of sulphur, two pounds of camphor, and two ounces of tanner's-bark, or saw-dust. Moisten all these ingredients with linseed oil.

Take mealed powder one pound, nitre four pounds, sulphur half a pound, and powdered glass six ounces; moistened with a little linseed oil.

Nitre half a pound, sulphur two ounces, antimony one ounce, and mealed powder three ounces.

Nitre

Nitre half a pound, sulphur three ounces, antimony one ounce, and iron file-dust half an ounce.

Nitre two pounds, mealed powder ten pounds, and sulphur one pound.

Nitre one pound, sulphur half a pound, mealed powder three ounces, and antimony one ounce.

Having mixed and prepared your ingredients, boil some flax in nitre-lye and camphor; then cut it small, and mix it up with any of the above compositions, which must be moistened with either the white of eggs, gum, or size: form this into little balls, of the size of a hazel-nut; strew them over with mealed powder, and let them dry.

To cause the stars to burn very bright, make your composition of one ounce and three quarters of nitre, three quarters of an ounce of sulphur, and a quarter of an ounce of powder.

Nitre two pounds, sulphur fourteen pounds and a half, and mealed powder six ounces.

The paste, or melted stuff above-mentioned, is also made use of for the same purpose, wrapped in tow.

To project Globes from a Mortar, and the Quantity of Powder required for that Purpose.

THE globes being of wood, it is requisite that the charges for them should be agreeable to their substance; for which end they are first weighed, allowing for each pound of its weight a quarter of an ounce of gunpowder. For example, if your globe weighs forty pounds, you must, to discharge it, allow ten ounces of powder.

The charge is thus performed; put the powder into the chamber of the mortar, and cover it with straw, hay, hemp, or flax, so as to fill it quite full; or if the chamber of the mortar be too big, get one turned of wood, equal in height and breadth to the chamber of the mortar that contains the charge of powder required; pierce this with a red hot wire,

 from

from the bottom of the wood to the centre of the bottom of the chamber in it, not perpendicular, but slanting. The place where the touch-hole begins must be marked, so that you may turn it to correspond with the touch-hole of the mortar. When you would load your mortar, cover the bottom of the chamber with a little mealed and corn powder, mixed together; and upon that put the wooden chamber, in which is the powder required to discharge the globe; then fix the touch-hole of the globe, exactly, upon the chamber, wrapping it in hemp, &c. to make it stand upright.

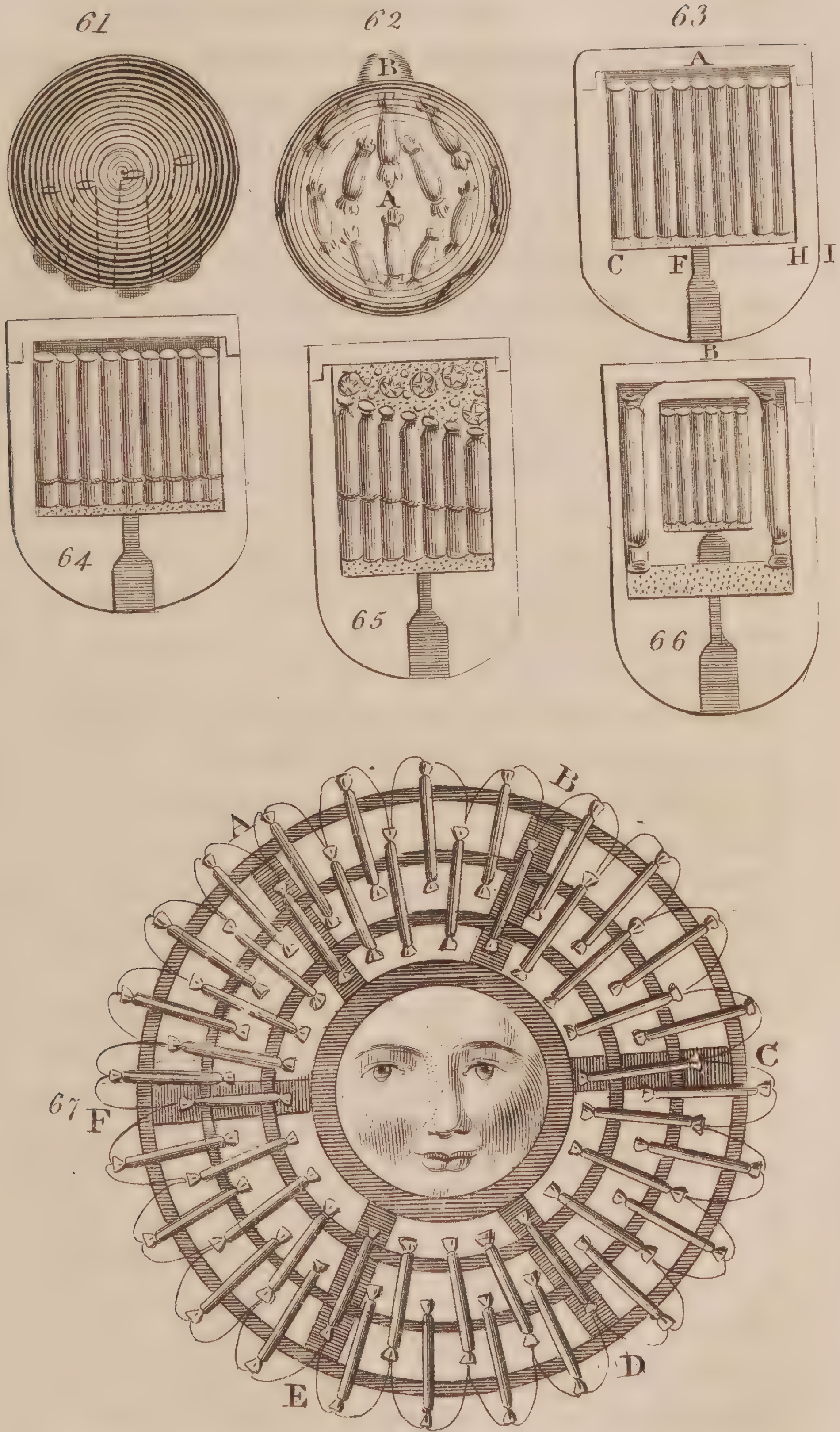
The mortars contrived on purpose for globes are more commodious, and we are more certain in projecting them: these are cast as follows: the length of the mortar with the chamber, without the bottom, is two diameters of the mouth; the bottom is one-fifth thick; the chamber is half the diameter of the mouth long, and a quarter wide; oval at bottom: the sides are an eighth of the diameter of the mouth thick, which is encreased at bottom to a third; the thickness about the chamber is a fourth part.

Some prepare these balls with nitre four pounds, sulphur one pound and a half, powder half a pound, antimony six ounces, and charcoal half an ounce.

Nitre four pounds, sulphur three pounds, camphor a quarter of a pound, and powder half a pound.

A fixed Sun, with a Transparent Face.

To make a sun of the best sort, there should be two rows of cases, as in fig. 67, which will shew a double glory, and make the rays strong and full. The frame, or sun wheel, must be made thus; have a circular flat nave made very strong, twelve inches diameter; to this fix six strong flat spokes, A. B. C. D. E. F.:—on the front of these fix a circular fell, five feet diameter, within which fix another fell, the


61
62
B
A
63
A
C F H I
B
64
65
66
B
A
C
67 F
E
D

the length of one of the sun cases less in diameter; within this fix a third fell, whose diameter must be less than the second, by the length of one case and one-third. The wheel being made, divide the fells into as many equal parts as you would have cases (namely, from 24 to 44): at each division fix a flat iron staple, which must be made to fit the cases to hold them fast on the wheel: let the staples be so placed, that one row of cases may lie in the middle of the intervals of the other.

In the centre of the block of the sun drive a spindle, on which put a small hexagonal wheel, whose cases must be filled with the same charge as the cases of the sun. Two cases of this wheel must burn at a time; but begin with them on the fells. Having fixed on all the cases, carry pipes of communication from one to the other, as you see in the figure; and from one side of the sun to the wheel in the middle, and thence to the other side of the sun. These leaders will hold the wheel steady while the sun is fixing up, and will also be a sure method of lighting both cases of the wheel together. A sun thus made is called a brilliant sun, because the wood-work is entirely covered with fire from the wheel in the middle, so that there appears nothing but brilliant fire: but, if you would have a *transparent face* in the centre, you must follow this method: take a piece of paste-board of a circular figure, like the sun's face, and cut out the eyes, nose, and mouth, for the sparks of the wheel to appear through; or, instead of this, paint a face on oiled paper, or Persian silk, strained tight over a small hoop: either of the faces are to be supported by three or four pieces of wire, at six inches distance from the centre of the wheel, so that the light may illuminate the face. In a similar way, you may place transparent motto's—" VIVAT REX;" or any other devices, suitable to the day of exhibition. Half pound cases, filled up ten inches with composition, will be a good size for

for a sun of five feet diameter; but, if larger, the cases must also be proportionably larger.

Spur-Fire.

THIS fire is the most beautiful and curious of any yet known, and was invented by the Chinese, but now is in greater perfection in England than in China. As it requires great trouble to make it to perfection, it will be necessary that beginners should have full instructions; therefore care should be taken that all the ingredients are of the best, that the lamp-black is not damp and clodded, that the saltpetre and brimstone are thoroughly refined. This composition is generally rammed in one or two ounce cases, about five or six inches long, but not drove very hard; and the cases must have their concave stroke struck very smooth, and the choak or vent not quite so large as the usual proportion; this charge, when driven and kept a few months, will be much better than when rammed, but will not spoil, if kept dry, in many years. As the beauty of this composition cannot be seen at so great a distance as brilliant fire, it has a better effect in a room than in the open air, and may be fired in a chamber without any danger: it is of so innocent a nature, that, though with an improper phrase, it may be called a cold fire; and so extraordinary is the fire produced from this composition, that, if well made, the sparks will not burn a handkerchief, when held in the midst of them; you may hold them in your hand while burning, with as much safety as a candle; and if you put your hand within a foot of the mouth of the case, you will feel the sparks like drops of rain. When any of these spur-fires are fired singly, they are called artificial flower-pots; but some of them placed round a transparent pyramid of paper, and fired in a large room, make a very pretty appearance.

Com-

Composition for the Spur-Fire.

SALTPETRE four pounds eight ounces, sulphur two pounds, and lamp-black one pound eight ounces. Or, saltpetre one pound, sulphur half a pound, and lamp-black four quarts. The spur-fire composition being very difficult to mix, and the manner of doing it quite different from any other, I shall here treat of it separately; for example, the saltpetre and the brimstone must be first sifted together, and then put into a marble mortar, and the lamp-black with them, which you work down by degrees, with a wooden pestle, till all the ingredients appear of one colour, which will be something greyish, but very nearly black; then drive a little into a case for trial, and fire it in a dark place; and if the sparks, which are called stars, or pinks, come out in clusters, and afterwards spread well without any other sparks, it is a sign of its being good, otherwise not; for if any drossy sparks appear, and the stars not full, it is then not mixed enough; but if the pinks are very small, and soon break, it is a sign that you have rubbed it too much. This mixture, when rubbed too much, will be too fierce, and hardly shew any stars; and, on the contrary, when not mixed enough, will be too weak, and throw out an obscure smoke, and lumps of dross, without any stars. The reason of this charge being called the spur-fire, is because the sparks it yields have a great resemblance to the rowel of a spur, from whence it takes its name.

To make Pulvis Fulminans, or Thunder in a Room.

THIS composition is simple, yet has a very curious effect; it is made three parts of saltpetre, two of salt of tartar, and one of sulphur, all ground to a fine powder, and well mixt. As the effect of this powder is quite different from that of gun-powder, so is there a different method of firing it, which is

is thus: Put about two tea spoonfulls of it into a fire-shovel, or iron ladle, and set it over a slow fire, and when it is quite hot, it will go off with a violent report. There is something surprising in the nature of this composition; for as the common powder acts every way equal, and makes the greatest noise when confined, this, on the contrary, acts only downwards, and makes the strongest report when not confined.

EXPLA-

EXPLANATION OF PLATE IV.

THAT the reader may have some idea of many of the chemical apparatus employed and mentioned in this work, it has been thought expedient to engrave them on one plate, whereby the whole may be seen at one view. It is advise-able, that it be thoroughly committed to memory, which will save the tediousness of a frequent reference, and give a quick-ness and facility in performing the operations themselves.

Fig. 1. A perpendicular section of a *Cupel* or *Test: c* the powdered bones kneaded with water, and firmly pressed into the iron ring, of which a section is seen at *a b*. There is a part which is hollowed, or dished out, for the reception of the metal to be tested.

Fig. 2. A *Muffel,* in which all articles are placed which are to undergo the operation of a strong fire, free from smoke, such as enamelled work, stained glass, &c.

Fig. 3. An *Ingot-Mould,* into the grooves of which melted metals are poured.

Fig. 4. A *Retort,* made either of glass or earthen-ware, and used in various distillations.

Fig. 5. A *Crucible.*

Fig. 6. An *Iron Cone,* inverted, with a handle and foot, into which metals, and other results of operations, are occasionally directed to be poured.

Fig. 7. A *Reverberating Furnace.*

a, The ash-hole door.
b, The fire-place door.
c c c c, Registers, to regulate the heat.
d, The dome, or reverberatory.
e, The conical funnel.
f, The retort in the furnace.
g, The receiver.
h h, Iron bars to sustain the retort.

Fig. 8. A *Furnace for colouring of Foils,* where the hand is represented in the act of performing the operation.

Fig. 9. A *long-necked Glass Alembic.*

A, The body of the matrass.
B, The neck of the matrass.
C, The head of the alembic.

Fig. 10. A *Glass Alembic.*

A, The cucurbit.
B, The head.
C, The aperture in the head, with the stopple.
D, The beak.

Fig. 11. A *Bolt-head,* or cap, which is affixed on the upper opening of a still. A still of this kind nearly resembles the reverberating furnace externally, *fig.* 7.—*d,* which is there the dome, may be supposed to be the upper half of the body of the still, the under half being hidden within the cavity of the fire-place; and in lieu of the conical funnel *e,* is substituted the above *bolt-head.* The exact proportions between the opening of the still, and the neck of the bolt-head, are not preserved in the plate, because the furnace would be, by this, too large for the work, or, on the contrary, the bolt-head would be too small.

Fig.

Fig. 12. A *Melting Furnace*, with its parts, *A. B. C. D. E*, taken from "Cramer's Art of Assaying Metals." We shall be very particular in the account of this furnace, as it is extremely well constructed, and useful.

Form and Dimensions of this Furnace.

The melting furnace is made of iron-plates, the inner surfaces of which are covered with *lute* *. The cavity of it may be formed according to an elliptical mould. 1st, Make a hollow ellipsis, the focusses twelve inches asunder, and the ordinate five inches long; cut it off in both its focusses, that it may assume the figure *A*. 2dly, Make in the hollow body, near its lower aperture, four holes, eight lines in diameter, and directly opposite (*c*, *c*,). 3dly, Fasten two flat iron rings (*d*,) almost an inch and a half broad, at both the upper and the lower inward edge of this oval cavity; and fill the inside of it with small iron hooks, jutting out about six lines, and three or four inches distant from each other. These, together with the rings just mentioned, serve to fasten the *lute*. Thus will the body of the furnace be made: only you must add at the outside, two iron handles (*e*, *e*,) to be rivetted on each side of it, that it may be taken hold of and moved. 4thly, Make the cover of the furnace, which may be formed like the part cut off from the ellipsis, see *fig. B*. Let this have an opening (*b*) made in it, four inches high, five inches broad at bottom, and four inches at the top; and adapt to this an iron door, hung on hinges, to shut close, and having at the inside a border fastened to it, answering exactly to the circumference of the door, and as prominent inwardly as the thickness of the *lute* to be applied to it: for the same purpose, let small iron hooks be fastened

* *Lutes* will be described at large in the next article.

to the inside of the door, which is intercepted by the said border. And lest this cover should be burnt within by the force of the fire, you must cover the inside of it with *the same lute*; therefore it must be likewise furnished with a ring and iron hooks, as was done to the part *A*. Besides this, you must fasten two iron handles on the outside of this cover (fig. B. *c c*,): then a round hole must be made in the top of it, being three inches in diameter, prolonged into a hollow tube (*d*) almost cylindrical, and a few inches high, upon which an iron funnel may, in case of necessity, be adapted. 5thly, The lining both of the body and cover of the furnace is made of the same materials as before-mentioned. Moreover, you must make for this furnace two moveable bottoms, viz. one to receive the ashes, and admit the air; the other to serve for reductions. The first is made with an iron plate, formed into a hollow cylinder, open at top, and to be shut at bottom with an orbicular iron plate, as with a basis, five inches high, of such a diameter, as that it may receive the inferior orifice of the body of the furnace (fig. *A*) the depth of half an inch, see fig. *C*: therefore, let an iron ring (*c*) half an inch broad, fastened on the inside of the said bottom, the distance of half an inch from its upper border, to support the body of the furnace put into it. Again, let this bottom have a square door, four inches high, and as many inches broad, that may be shut closely, that you may increase or diminish the draught of the air, at pleasure. On the left side of this door, about half the height of the bottom, let a round hole (*d*) be made, one inch and a half in a diameter, to admit the pipe of the bellows when need requires. Next to this, let another bottom part be made of the same matter and figure as the foregoing: let it be likewise of the same diameter, but two inches higher, so as to be seven inches high. Let it likewise have round it a similar iron ring below its upper border, to support the body of the furnace to be received in it. But let a hole, two or three inches broad,

and

and one inch high (fig. *D.*) be cut out at *c* just below the ring in the side of this bottom part; and let another round hole (*d*) be made in the left side of this first hole, fit to admit the pipe of the bellows. Further, let another round hole like the foregoing (*e*) be made on the right, one inch from the bottom; then let the whole inside of this bottom part (the part above the ring excepted) be over-laid with *lute*, and a bed be made at the bottom, of a figure like that represented by the line (*f*, *g*, *h*,). The matter of which this is made is common lute pulverized, passed through a sieve, and mixed with such a quantity of sifted charcoal dust, as may be lightly coherent, when moistened, mixed together, and pressed down. Of this matter the bed is made at bottom, like a segment of a sphere, having in the middle a small cavity somewhat lower, and made extremely smooth.

Use of this Furnace.

THIS furnace is chiefly fit for fusions, which may be made in it, with or without vessels. When you are to melt *with a vessel*, put the body of the furnace (fig. *A.*) upon the first bottom (fig. *C*,) which has a door to it, to open on hinges: introduce two iron bars through the holes of the furnace, (fig. *A. c, c*,); put upon them the iron-grate, which you are to introduce through the upper mouth of the furnace: then put in the middle of this grate a *brick* or square *tile*, very smooth, warmed, and dry; otherwise, the vessels put upon it, especially the large ones, are easily split by the moist vapours coming out of it by the heat. Let the height and width of these be a small matter broader and higher than the bottom of the crucible or vessel set upon it; for if it were less high, the bottom of the vessel could not be sufficiently warmed; and if it were less broad, the vessel might easily fall from it: then put upon this *tile* the vessel containing the matter to be melted, and surround it immediately with coals on every side, which must be ranged with care. The fire is governed

and

and regulated by opening or shutting the door of the ash-hole *b* (fig. *C.*); you may excite it, by putting the cover (fig. *B*) upon the body of the furnace; and if, besides, you put a funnel upon the cylindrical mouth (*d*) of this cover, the melting fire becomes still more violent: but if you moreover introduce the bellows through the hole of the bottom part *d* (fig. *C.*); and the joint of the furnace with the bottom part and the door of the ash-hole (unless it can be stopped very close of itself) be tightly closed with *Windsor loam,* the fire may be excited to so powerful a degree, as to surpass the heat of a smith's forge. Another advantage of this method is, that the vessels are not so easily broken, because the blowing of the bellows cannot affect them immediately, and because a fire perfectly equal is excited on every side. One may easily examine with this *apparatus,* how *stones* are affected by the violence of the fire only. Now, if you have a mind to perform any operation *without a vessel,* and with a naked fire; for instance, to melt and reduce *copper, tin, lead,* and *iron,* or their ores; the body of the furnace must be put upon the other pedestals, having a bed in it (fig. *D*). However, you must, before this, open with a knife the oblong hole (*c*) and the round one (*d*) of this bottom part, which are stopped with the lute sticking to the inside: then you apply at the round hole (*d*), on the left side, the bellows, in such manner that the nozzle of it being directed obliquely downwards, may blow strongly against the bed (*f, g, h,*): by this means, all the ashes that fall into the bed are blown away, and the strength of the fire determined to such a degree, that all the melted bodies that fall into the said bed, remain in their state of fusion; and were it otherwise, the melted bodies would immediately wax cold, and adhere in grains to the bed, whereas they ought to have melted into one regular mass. The oblong hole in the fore part of this bottom part (*c*) serves to discover, by means of a poker, whether the matter in the bed be melted or not: it serves likewise to take away through it whatever might stop the bellows,

lows, and in some cases to take away the *scoria*, then you put, first, coals into the furnace, one span high, and blow them well with the bellows, to make them burn, that the bed may be very hot before the matter to be melted is put in; for if this is not previously done, the melted mass seldom runs into a *regulus*, but remains dispersed among the *scoria*, which soon grow hard. The bed being well heated, and fresh coals added to the fire, put into it such quantity of the matter to be melted as cannot hinder the fire from being carried to the requisite degree; which cannot be determined otherwise than by experience: again, put fresh coals, and upon them another quantity of the matter to be melted; they may be, like *strata*, lie one upon another: but if the mass, once melted, could not long sustain the strength of the fire, or if you had a mind to melt a greater quantity of the matter than what can be contained in the bed, you must open the round lower hole *e* (fig. *D*), that you may make a channel passing from that hole through the lute, and reaching to the small cavity at the bottom of the bed *(g)*: to this hole, at the outside, apply an earthen dish like the bed within, or any other proper recipient, surrounded with burning coals, into which the matter melted, running from the bed through the hole *e* (fig. *D.*) may be collected, as is represented by *figure E.*

Furnaces of the foregoing description, together with crucibles, black-lead pots, and many other chemical apparatus, were formerly imported from Germany, at great cost and trouble. They are now made in England *, and with considerable advantages, being more portable, cheaper, and readier. A complete furnace, capable of being worked in a parlour chimney, may be had, which will create little trouble, and will require no assistance from the bricklayer.

* They may be had, of all sizes and prices, of Messrs. Pugh and Speck, at their manufactory, at the bottom of Booth-Street, Spital-Fields; likewise of Mr. Knight, ironmonger, Foster-lane, Cheapside.

We

We shall now give a short account of what is called Dr. Black's Portable Furnace, which is very highly esteemed where a great heat is required. It consists of an oval iron case, about 22 inches high, 20 in its largest diameter, and 15 in the shortest, lined with fire bricks for about three-fourths of its height from the top, which forms the body of the furnace, and the first elbow of the chimney, whilst the lower part, which is not lined, forms a very spacious ash-pit. Being very heavy, it is put upon castors, by which, with the assistance of the ring handles on the side, it may be moved along a floor without difficulty. The body of the furnace is cylindrical, but a little oblique, that the flame of the fuel may heat the sand-bath somewhat more equally than if it were a straight cylinder. The breadth of this cylinder is 8½ inches, and its height 15; the grate lies across the bottom. This fire-place has the following six openings above the grate: the highest is the large opening at the top, which, when a sand-heat is employed, receives the sand-bath; and when this is not wanted, is covered by a thick iron plate, lined with clay, in the centre of which is a small hole, fitted with a stopper, through which the state of the fire may be seen without scorching the face. The next opening is the elbow of the chimney, which widens as soon as it takes a perpendicular direction, and for the first few inches forms a part of the iron case of the whole furnace, and is lined with clay, after which it is elongated by a conical iron chimney. Even this small length of flue is sufficient to keep up a very considerable heat when the fire is well supplied with fuel; but to raise it to the intensity requisite for melting cast iron, it is necessary to add several feet of iron pipe, if it is set under an open brick chimney, or else (which is often more convenient) to close the throat of the brick chimney with an iron plate, leaving only a round hole in the middle, into which the upper part of the pipe closely fits. In this case no further length of iron flue is required to give a very strong draught through the furnace, capable of raising heat enough

for

See the Explanation, Page 60.

PLATE 4.

2 Plates in 1.

for almost any purpose of the chemist. Opposite the chimney hole in the body of the furnace, and a little below it, is an opening which serves to introduce fuel when the upper opening is engaged by the sand-bath, and the heat of the latter may also be lessened at pleasure, by leaving this hole open, which causes a draught of cold air to rush in directly round the bottom of the sand-bath. The next openings are two small round holes, placed directly opposite each other at right angles with the perpendicular of the chimney, and serving to introduce an earthen or iron tube. Below these is the sixth opening, cut of the proper shape to receive a muffle, for which it is intended. The openings are properly fitted with very thick stoppers, which are further covered with pieces of iron plate, closely sliding in grooves. The ash-pit is merely the lower part of the iron case that incloses the whole furnace, and is furnished with two doors, by which the draught of air may be regulated. A great variety of operations, and on a tolerably large scale, may be performed in this useful furnace, which is very durable, and being heavy and substantial, it is not liable to be damaged by accidental blows, or easily displaced; and it is, besides, extremely safe in a room, provided the chimney is clean. The iron case should be now and then rubbed with black lead, to prevent its rusting. This arrangement of the chimney allows very free access to the body of the furnace, and the thickness of the walls prevents the operator from being at all molested by the intenseness of the heat. It is necessary to say something relating to the fuel best adapted for furnaces. Wood and charcoal were formerly the only materials employed for this purpose in this country, and are still so in most other parts of the world; the first, where a large volume of flame is required, and the latter, for a strong heat without flame. Thus, glass-house and reverberatory furnaces were supplied entirely by dry faggots and iron forges, by charcoal. Wood faggots give a strong clear flame unmixed with sulphur, and with but little smoke, and burn to a clean ash, which also is

valuable

valuable for the alkali it contains. From its freedom from sulphur it must be in many instances better than coal, and it seems to have no other disadvantage than the rapidity with which it burns out in a strong draught, being so much more bulky than coal, that only a comparatively small quantity at a time can be thrown into a furnace. Charcoal is a most valuable fuel for furnaces. It kindles readily, burns with a very strong clear heat, and requires a much less draught of air for combustion than coak or charred coal; it contains no sulphur nor any earthy or metallic matter, and hence it never runs into a hard vitreous clay, as coak does, but burns away into a clean light ash, which falls through the bars of the grater, without choaking and hindering the draught of air, or melting down the clay walls of the furnace. The flues or chimnies, also never collect any soot or foulness, and therefore never require cleaning. A much greater range of heat may be kept up by charcoal than by any other fuel, for its utmost intensity of heat fully equals that of coal or coak; and besides, it affords the great advantage of burning away very slowly, with a gentle and pretty steady temperature, when the supply of air is just sufficient to keep the fire alive. Charcoal (besides being expensive) has however the inconvenience of being too light to bear a very strong blast of air in common blast furnaces, except it is in larger pieces than is often convenient, and it also burns out very rapidly in a strong draught, so as to require a constant supply. There appears to be very little reason for preferring the charcoal of one wood over another, provided both are equally well burnt. It may be added, that the wood intended for charcoal is always previously barked; when this is neglected, the charred bark, as soon as it is kindled, burns with a short, but prodigious, eruption of sparks, often inconvenient to the operator. Coal is the fuel almost invariably used in this country for common culinary purposes, for all manufacturing fires where a moderate heat is wanted, and the substance is not injured by the smoke, or can be put out of the reach of it (as in brewers'

brewers' and distillers' coppers) and in the laboratory for heating sand-baths for smiths' forges, and also for the reverberatory furnace. It gives a large, strong, and very lasting flame; but for any intensity of fire, it requires a pretty large and high chimney, and a wide ash-hole. Coak gives a very strong heat without flame, and this is the general material for strong wind and blast furnaces, where an intense and durable heat is required. Coak, in the way it is commonly prepared, always give out at first a blue sulphureous flame, which ceases when fully red hot. On account of the great density of this substance, it bears the blast extremely well; but being a much less pure combustible than charcoal, and containing a mixture of earths and oxyd of iron, it is very apt, when nearly burnt out, to cake together in an intense heat, and to run into a tough cohesive slag, quite glassy and sonorous when cold, and which melts on the surface of the crucibles, and can hardly be detached from them. Coak alone is not easily kindled, and requires a much more powerful draught of air than any other fuel, so that it cannot be burned in an open grate, except it is in very large quantity. Its combustion is materially assisted; and its vitrification, when nearly burnt out, is much prevented, by mingling it with about its own bulk of charcoal, and these two together form the very best material for the furnaces that require an intense heat.

OF LUTES.

In many chemical operations, the vessels must be covered with something to preserve them from the violence of the fire, from being broken or melted, and also to close exactly their joinings to each other, to retain the substances which they contain ,when they are volatile and reduced to vapour. For this purpose, several matters are employed, called in general *lutes*.

The lutes with which glass and earthen-ware retorts are covered, ought to be composed of nearly equal parts of coarse

coarse sand and refractory clay. These matters are to be well mixed with water and a little hair, so as to form a liquid paste, with which vessels are to be covered, layer upon layer, till it is of the required thickness. The sand mixed with the clay is necessary in this lute, to prevent the cracks which are occasioned by the contracting of clay during its drying, which it always does when it is pure. The hair serves also to bind the parts of the lute, and to keep it applied to the vessel; for, notwithstanding the sand is introduced into it, some cracks are always formed, which would be likely to tumble off in pieces.

The lutes with which the joinings of vessels are closed, are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels. When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or linen, covered with a tough paste of flour and water. In such cases also, slips of wet bladder, which will affix themselves close to the parts, are highly convenient. When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quick-lime slaked by the air, and beat into a liquid paste with whites of eggs. This paste is to be spread on linen slips, which are to be applied exactly to the joining of the vessels. This lute is convenient; it easily dries, becomes solid, and sufficiently firm. Lastly, when saline, acid, and corrosive vapours are to be contained, we must then have recourse to the lute called *fat lute*, which is made by forming into a paste some dried clay finely powdered, sifted through a fine lawn sieve, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, *i. e.* linseed oil which has been made *drying* by boiling it with litharge—sold by the colourmen. This lute will take and retain the form that is given it. It is generally rolled in cylinders of a convenient size. These are

to

to be applied, by flattening them, to the joinings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen, spread with lute of lime and whites of eggs. These slips are to be bound round with pack-thread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone.

Another lute is made by using a strong solution of glue to the lime, instead of the white of egg. It sets equally soon, and becomes very hard. A mixture of liquid glue, white of egg, and lime, makes the lut d'ane, which is so firm that broken vessels united with it are almost as strong as when sound. None of these lutes, however, will enable these vessels to hold liquid, for any great length of time. Milk or starch with lime make a good but less firm lute. A very firm and singular lute of this kind is made by rubbing down some of the poorest skimmed-milk cheese with water to the consistence of thick soup, and then adding lime and applying as above. It answers extremely well. Lime and blood, with a small quantity of brick-dust or broken pottery stirred in, is used in some places as a very good water-cement for cellars and places liable to damp. Paris plaster, mixed with egg, milk, glue, starch, or any mucilaginous liquor, also makes a good lute. Some artists mix other earths with the above materials. Thus a very good cement is made with equal parts of clay and lime, about one third of flour and white of egg; or as is used by many of the aqua-fortis makers, a mixture of colcothar, lime, and white of egg. All the above-mentioned cements with lime become very hard by drying, insomuch that they cannot be separated from glass vessels without the help of a sharp knife and some violence, and hence delicate vessels and long thin tubes cemented with it are apt to break when the apparatus is taken down, and sometimes even by the mere force of contraction

in

in setting. It is a great advantage, however, that they may be applied immediately to any accidental crack or failure of the lute already on, notwithstanding a stream of vapour is bursting through, and in large distillations it is of advantage always to have some of the materials at hand. Another species of lute is that which is commonly applied round glass retorts, when distillation with a full red heat is wanted to protect them from the sudden action of the fire, and to give them firmness, and enable them to bear this heat without flattening or falling together when red-hot, or melting with the fuel. A glass vessel, so prepared, with a thick earthen coating, may be considered as an earthen vessel glazed on the inside. The substance used is a mixture of sand with just sufficient clay to make it adhere together, beat up with some kind of fibrous matter so as mechanically to encrease the tenacity. A natural earthy mixture of the kind is Windsor loam, or an equally good one may be formed with coarse sand and clay, or better with fragments of pottery coarsely ground (the fine part being separated by sifting and rejected) mixed with more or less clay according to the quality, so that it will just mould together when wet. For the fibrous matter, some use horse-dung, which appears the best, others, chopped straw or chaff, others, chopped horse and cow hair, or tow, all of which answer the same purpose. A small quantity of these will suffice. Beaumé recommends about an ounce of cow's hair to five pounds of the earthy mixture. A good deal of water should be added when the materials are mixed, and much manual labour is required to diffuse the hair equally through the mixture. To apply it to a glass vessel, a retort, for example, take a sufficient quantity of the lute, spread it out flat on a table, lay the bottom of the retort on the middle of the mass, and then turn up the edges of the flat cake, and bring it over the rest of the glass, pressing it down with the fingers till it applies uniformly and closely. By this method the lute is without seam, and is much more likely to dry in the fire without cracking. Or else,

bring

bring the lute with sufficient water to the consistence of thick soup, dip the retort in, and it will come out thinly coated. Turn it round before the fire, and when dry dip it again in the lute to give a second coating, and so on to the required thickness, which may be from a quarter to half an inch. A lute similar to this is used as a lining to iron furnaces, to confine the fire and prevent the iron from consuming by the constant heat. This lute is just so fusible as to begin to agglutinate in a full red heat, and hence, if it remains sound till thus hot, it will form an impenetrable coating to the glass within, from which it cannot afterwards be detached. The covers of crucibles, and other vessels intended to bear fire, may be luted with this earthy mixture. It is rendered still less liable to crack on the first heating, if, when thoroughly dry, it is smeared with linseed oil. Often a fire lute is required to join the covers to crucibles, or for similar purposes, so as to keep them air-tight when hot. A very valuable composition of the kind is made of glass of borax, brick-dust, and clay, finely powdered together, and mixed with a little water when used. No very great nicety is required in the proportions, but about a tenth of borax is quite sufficient to bring the earths to that state of semi-vitrification which is desired. Litharge may also be used instead of borax, but the latter is by far the best, as it promotes that thin spreading fusion which is best calculated to be equally applied over an uneven surface, and besides, if a portion of the litharge-lute were to drop into the crucible it might possibly be reduced, and lead introduced into the results of the experiment. A cement said to be useful to stop cracks of iron vessels intended to be strongly heated, is made of six parts of clay, one of iron filings, and linseed oil enough for mixture. A very firm cement is made by four parts of rosin, one of bees wax, and when melted, 1 part of fine brick-dust stirred in. This adheres with extreme firmness. Table knives are cemented to their handles by this mixture, and turners use a similar composition in some fine works, to fix

9 them

them to the lathe. Chaptal found, after many trials, that the penetrating vapours of sulphureous acid, in the manufacture of alum, were completely confined in a wooden chamber, lined very carefully with a mixture of equal parts of pitch, turpentine, and wax, boiled till all the essential oil was dissipated (which was known by the cessation of the bubbles) applied melted to the wood, and spread with a hot trowel over the joints. Vintners stop leaks in their casks with melted suet rubbed over, when cooling, with sifted wood-ashes, or previously mixed with the ashes in melting. The use of gum arabic, dissolved in water, for cementing paper labels to bottles, and a great variety of miscellaneous purposes, is known to every one. A still better cement for the same uses is isinglass dissolved in vinegar, to a pretty thick consistence when warm. This congeals on cooling, and before it is used it should be gently warmed.

PART

PART II.

A VARIETY OF

CURIOUS AND VALUABLE EXPERIMENTS

ON

GOLD AND SILVER;

SHEWING THE METHOD OF TESTING, REFINING, SEPARATING, ALLAYING, AND TOUGHENING THOSE METALS; TOGETHER WITH OTHER RECEIPTS, FOR GILDING, &C.

PREVIOUSLY to entering upon the several detached receipts upon gold and silver, it may be proper to give a brief sketch of metallurgy; or, in other words, "The art of extracting and purifying metals, in the great way."

After trial has been made on a small scale (which is called an Assay) whether any particular mine is likely to be profitable, the workmen proceed as follows: They dig a perpendicular square pit, large enough to admit ladders, whereby they may descend. Across the mouth of this pit, which is called a shaft, an axis is usually laid, for the purpose of raising buckets loaded with the mineral; and pumps are also placed, for carrying off the drainage water. If the depth of the mine be so great as to exceed the due pro-

proportion of the first square pit, an horizontal drift is formed, at the end of which a new shaft is sunk, and so on alternately till they reach the bottom of the ore-mine. The drifts, which resemble galleries in some measure, are propped up by art, if the stratum through which they pass is of too crumbly a texture to support itself. Regular supplies of fresh air ought at all times to be kept up. Sometimes it is practicable to open an immediate passage to the plane below; but if this cannot be effected, a new shaft is sunk at that part of the drift or gallery which is furthest from the former shaft, so that if one of these is higher than the other, the air easily circulates. When, however, they are equally high, a fire is kindled in a furnace over the mouth of one of the shafts, and thus a supply of air is gained. Again, the pumps which are usually employed to take off the drainage water are sometimes insufficient for the purpose, for a sudden burst of water will in a moment inundate the galleries; in this case, the workmen, having warning by the peculiar sound of the rock when it is struck, cut the rock to give vent to the water, and retreat behind a door which they have prepared, which shuts out the fluid from overtaking them.—Mines are subject to elastic vapours, which are extremely dangerous to the workmen: their effects are prevented by rapid currents of fresh air, or by detonation.

When the mineral is brought out of the mine, it is pounded, washed, roasted, melted and refined. For pounding it, large knockers are moved by some strong mechanical power; and after it is pounded, it is put on inclined tables, to be washed, that the water may carry off the gangue, matrix, or immediate bed of the ore. When ores contain sulphur they should be roasted in the open air, otherwise they may be roasted in the furnaces in which they are to be afterwards melted. Some ores will melt by themselves; others require a flux for fusing them, and must be brought in contact with charcoal. The furnaces which are employed are of various kinds; but,

sometimes, the same furnace will answer two purposes. Although metals are by these means reduced to a metallic state, yet they are frequently mixed together, of various kinds, and they therefore require some further processes to separate them.

OF GOLD.

GOLD, which has been termed *sol*, the *sun*, and *king* of metals, is a perfect metal, of a splendid yellow colour, and not liable to alteration. The regular figures of native gold are the octahedron and the trapesium; but it frequently presents itself in irregular forms, in branches, in dendrites, filiform in their plates, or in grains and spangles. It is found chiefly, and in the greatest abundance, in the gold mines of Mexico and Peru, in South America. But it is likewise met with in several rivers in France, as the Rhone, the Arriege, &c. floating along with their sands in spangles of pure metal. It is almost found in the metallic state. It unites so perfectly with copper, that the specific gravity of the alloy is greater than the mean of the specific gravities of the metals of which it is compounded. This alloy is also harder than the gold, on which account it is admitted in commerce to use $\frac{1}{11}$ part of copper in the manufactures of the goldsmith. Being unaffected by fire or air, and soluble only in the most powerful acids, it is preferred before all the metals, for coin, and for vessels, trinkets, and very costly ornaments. Its great ductility to be shortly noticed, and its extreme tenacity have occasioned it to be employed to gild wood, pastes, and metals; to cover thread in the manufacture of lace, &c. When gold is very pure it loses in water between a nineteenth and a twentieth of its weight. Its specific gravity is 19. 26. Its hardness is not very considerable, being in an intermediate state between the hard and soft metals; that is, less hard than iron, platina, copper, and silver; and harder than lead, tin, &c. It is less fusible than mercury, tin, lead, and silver; but more easily fused than

 platina.

platina. It is extremely malleable, and spreads readily under the hammer; and by the hand of a skilful artist may be wrought into any shape or form. So wonderful and surprising is its ductility as to nearly exceed belief. From absolute experiments, an ounce of gold may be beaten into a leaf that will cover ten acres of ground; and an ounce of gold may be made also to cover, perfectly, a silver wire that is 444 leagues, or 1332 miles, or 2,344,320 yards, or 7,032,960 feet, or 84,395,520 inches, in length. Dr. Black says it would take 14,000,000 films of gold, such as is on some gilt wire, to make the thickness of an inch; but as many leaves of paper would make $\frac{3}{4}$ of a mile in thickness. A single grain of pure gold has been extended over an area that is more than fourteen hundred inches square; and a wire of the same metal, only one-tenth of an inch in diameter, has been found so tenacious as to support five hundred pounds weight, without breaking. Long hammering will make it rather brittle, but heat soon restores its ductility, which is termed nealing or annealing. The colour of gold sometimes varies, but this is owing to some mixture or alloy. When it is pure, it is called gold of 24 carats; and as the number of carats decrease, so much the more is the alloy (generally of silver or copper); thus, one quarter of silver, and one quarter of copper, to one half of gold, incorporated together, make a gold of 12 carats; and this is specified on the bars or ingots. Gold is unalterable by air or water; and the dulness which may appear occasionally on its surface is entirely owing to extraneous matters, and not to rust. The action even of a common fire, long continued, makes no alteration of its substance: but it melts at 32° of wedgwood, and if pure is of a beautiful green colour when in fusion. When it has acquired a vivid redness, it soon melts; but it emits no fumes, and suffers no loss of weight whilst in fusion. Kunckel kept gold in a glass-house furnace for a month; and Mr. Boyle kept it in a similar furnace for a much longer time, without the loss of a single grain. It may

may be volatilized by the heat of a very powerful burning glass, or by combustion, urged by a current of oxygen gas. Simple chemical agents are unable to make any impression on gold, but compound bodies, such as nitro-muriatic acid * and sulphuret of potash †, dissolve it powerfully. Gold has a much greater affinity for mercury than any other metallic substance has, and it will therefore decompose amalgams of any other metals with mercury. The amalgam of gold with mercury is of a higher and more solid colour in proportion to the greater quantity of gold. This amalgam is liquified by heat, and will crytallize on cooling, like most of the compounds of this kind. It is used principally by the workmen in gilding in *water-gold,* termed *water-gilders.* An alloy of silver with gold produces *green-gold,* which is used by the jewellers.

As gold is a standard, used by most nations, to represent the value of the productions of nature and art, it is highly necessary and important to discover its extreme purity, and to be able to detect any fraud which may have been used to encrease its bulk. Chemists are in the possession of a method of *testing* it, and this peculiar process is termed *cupellation;* which is as follows.

Method of testing Gold by Cupellation: used also in testing of Silver.

THE process of cupellation is the art of destroying, vitrifying, and scorifying all the imperfect metals which are destructible, and which are extraneous to pure gold and silver. We see then, that the examination, or *assay,* of the purity

* Nitro-muriatic acid is still called in the shops aqua regia: it is formed of nitrous acid or nitric acid, and muriatic acid, in the proportion of two to one. The compound is of less specific gravity than either of its constituents.

† Combination of sulphur and vegetable alkali. Compounds of sulphur, with the metals and alkalies, are all denominated sulphurets, thus we have sulphurets of iron, potash, &c.

of gold or silver, separately considered (for when they are mixed, and purified from their several ores, on a large scale, it is termed *refining)* is no other than ascertaining the difference of weight between the residue of the metal, after the operation, and in its primitive state. A quantity of lead, proportionate to the supposed quantity of alloy, is mixed with either of the purer metals. The principle on which the process of cupellation is founded, is that of mixing the alloyed noble metal with a considerable portion of lead, exposing the whole to a melting heat with access of air, and thus converting to an oxyde both the lead and every other base metal present in the mass, till the noble metal is left behind perfectly pure. This process is performed both in the large way in extracting silver from the ore and refining it, and in the small way in assaying those mixtures of gold and silver with different alloys which are used in such large quantities for plate, coin, &c. &c. The former, indeed, is technically called refining, and the latter, only cupellation; and some little variation in the management of each takes place, but the principle in both is precisely the same. Cupellation is usually performed in a furnace contrived for the purpose, and capable of giving a pretty intense heat. The body of the furnace is a hollow four-sided prism, in the middle of which is fixed an earthen vessel called a muffle, of an oven shape, vaulted at top, entirely open at one end, and with a flat floor at bottom. The open end of the muffle comes in close contact with a corresponding hole in the side of the furnace, and is luted to it, and the closed end projects as far as the centre of the furnace. By this contrivance the muffle is heated by the fuel round it, whilst not a particle of the burning charcoal can fall into its cavity, and a gradation of heat is also obtained within it, being the most intense at the closed end, which is in the centre of the fire, and the least at the open end, contiguous with the hole in the side of the furnace. The cavity of the muffle being large in comparison with the vessels which it is to contain, a considerable body of heated

air

air is constantly circulating over the melted metal, which is necessary to keep up the constant oxydation of the lead and alloy on which the process of cupellation depends. But as it would be nearly impracticable to keep up the requisite heat within the muffle, whilst one side was intirely open to the external air, a small vestibule or shelf of iron is made to project a few inches from this opening, on which several long cylinders of charcoal are heaped up whilst the process is going on, which take fire by touching the end of the red hot muffle, and partially block up the opening, so as fully to heat the outer air in passing to it. The melted metal is contained in iron ringlets; see plate IV. fig. 1. or in small earthen vessels called cupels, which are small solid cubes or cylinders about an inch or an inch and a half across, and with a small depression at top, which lodges the melted globule. The cupels may be made of any earth of little cohesion, such as the ashes left after the lixiviation of the saline residue of burnt wood, which are much used in refining; but for cupellation, or assaying in the small quantities, the cupels are made entirely of bone-ash, or phosphat of lime, which possesses the qualities of porosity and infusibility in an eminent degree. This is ground to a fine powder, then a little moistened with water, and the mass (which possesses scarcely any cohesion) is forcibly struck into an iron or a brass mould, where it takes the requisite form, and on drying becomes solid enough for use. The cupels are so small, that several of them may be ranged side by side on the floor of the muffle; and they are so extremely porous, that the fused oxyde of lead sinks into their substance with as much ease as water into a lump of chalk; but all of the globule of metal that remains in the metallic state is detained in the little cavity on their surface. It should be observed, that the cupels cannot absorb more than their own weight of litharge at the utmost, so that the quantity of metal used, and the required proportion of lead, must be regulated accordingly.

Several

Several curious circumstances take place with mixtures of gold with other metals. When pure gold is mixed with lead and cupelled, the whole of the lead is not separated, as it is with pure silver, but a small portion remains combined with the gold, sufficient to impair its colour and ductility. If, besides gold and lead, the mixture contains copper to the amount of $\frac{1}{24}$ of the gold, the whole of the lead will now be separated in cupellation, but almost the whole of the copper will remain. If, in addition to the above ingredients, the alloy contains a somewhat greater proportion of silver than it does of copper, this latter is separated by cupellation; but a little of the lead remains. But if the amount of silver equals or exceeds that of the gold, all the lead and copper are separated, and only the gold and silver remain. As therefore the object of cupellation is to separate the whole of the alloy of base metal, it is neceseary, in assaying gold, to add first a very considerable quantity of silver, then to work off the copper, and other base metal, by lead on the cupel, and afterwards to separate the gold and silver by the process of parting, as it is called, by means of nitric acid, which will be described presently. The cupellation of gold is conducted in the following manner: the quantity of copper, or other alloy present, being first estimated as accurately as possible in the way that will be presently mentioned, as much fine silver is added to the mixture as will make the gold only a fourth of the mass when the base alloy has been removed. If the gold is already alloyed with any silver, a proper allowance is of course made for the estimated quantity; to the mixture is added the requisite quantity of lead. After this, it is exposed, for a length of time, to the strongest heat of a reverberating furnace, till the imperfect metal, lead, is totally scorified, or till the gold or silver, which ever is the subject of the operation, assume a dazzling brightness. At this time it will be found, that the bone ashes have absorbed the impurities, and the pure metal forms a bright metallic button in the centre of the cupel. In determining the quantity

tity of impurity the purer metal contained, it is considered as consisting of *twelve* parts, which are called *penny-weights,* each of which are divided into twenty-four grains. If the mass under consideration has lost in the cupel only the twelfth-part of its weight, it is said to be of *eleven penny-weights;* if it has lost only a twenty-fourth part of its weight, it is said to be of *eleven penny-weights and twelve grains* fine.

Of separating Gold from Silver.

ALTHOUGH gold and silver may be perfectly separated from the more imperfect metals by the afore-mentioned process, yet they cannot be separated from each other by the same means, because they equally withstand the heat of the furnace: other methods, therefore, are employed, which are termed *parting,* viz. by *solution,* by *cementation,* and in *the dry way;* of which, separately.

Parting of Gold from Silver, by Solution.

THOUGH the name of the parting assay is applied in general in chemistry to every process of which the object is to separate metals from one another, this denomination is more particularly applied to the alloys of gold and silver, because these two metals, being more important and more valuable than all the rest, require a degree of care and attention which those do not. There are different processes for parting a mass composed of gold and silver. In general we begin by endeavouring to ascertain the nature and the proportion of the alloy, by the application of a simple means, but which requires much exercise and habit in order to succeed in it; accordingly in the workshops this operation is often committed to one particular person. It is founded, like the parting assay itself, upon the solubility and oxidability

bility of silver, and the unalterability of gold. It consists in rubbing the alloy upon a hard stone, or piece of jasper, which receives a mark from it, upon which some drops of aqua-fortis are poured; if it be only silver, the whole is carried away; if it be only gold, the mark remains entire: what remains, compared with what has been taken away, serves to determine the standard of the gold. It is evident that the same means will serve equally for gold alloyed with copper; it is oftener employed for the latter alloy, which is much more frequent than the first in goldsmith's work. We may become accustomed to judge skilfully from this first assay, by the touch, or by the touchstone, by beginning to practice with known alloys of all possible proportions, which are called touch-needles. Even the colour of the mark left upon the stone by the alloy, indicates to experienced persons the nature, or at least very nearly the proportion of its parts. But though this first assay is sufficient to enable us to judge of very small pieces, though it affords a first notion sufficient to guide us in the operation which precedes that of parting the alloyed mass, it is far from being satisfactory for those who wish to ascertain with precision the nature of the alloy of gold and silver. There are several processes for making the parting assay of an alloyed mass of gold and silver: there are particularly distinguished the dry parting, the parting by cementation, or concentrated, the inverse parting, and parting by nitric acid, or aqua-fortis. The first is made by means of sulphur; the second, by a mixture of sulphat of iron and sea-salt, which are cemented with leaves of the alloy in a crucible: it is the oxygenated muriatic acid which here acts upon the silver. The inverse parting is made by the nitro-muriatic acid, which dissolves the gold, and reduces the silver into insoluble muriate. The three first kinds of parting are rarely used, because they are either embarrassing or not sufficiently exact: it is the parting with the nitric acid which is the most employed, because the most simple and the most certain. In order to perform the ordinary process of

of parting, that which is subsequent to the touch, and ought to afford a positive knowledge of the nature of the alloy, it is first necessary that the proportion of the silver be at least double that of the gold. Most assayers require even that the silver should form three-fourths of the alloy; on which account silver is frequently added to the mass: this is called quartation. When this addition has been made, when the alloy, having been well cupelled, contains nothing else but silver and gold, the button, which is generally taken of two dwts. is flattened upon a steel anvil; it is passed through the flatting machine, taking care to anneal it, in order to prevent its cracking, and that the plate which is obtained may be perfectly entire: this plate is made sufficiently strong to resist and to preserve its form, though thin enough to be easily bended; it is rolled upon a pin, or upon a mould of iron made expressly for the purpose; it is formed into a cornet, which is introduced into a small conical matrass: upon this is poured about seven or eight times its weight of well purified nitric acid, diluted with one half of pure water. The vessel is placed upon a sand hearth till the effervescence and the disengagement of nitrous gas are well established; it is heated gently as long as red vapours arise; when they arise no longer, and when the effervescence ceases at the moment in which the matrass is removed from the fire, the operation is terminated, the silver is for the greater part dissolved, and the gold remains with the form of a cornet or coil, and of a deep purple colour. However, in order to be certain of carrying off all the silver, and not leaving a surplus of this metal in the gold, after having gently decanted the first acid from above the cornet, four more parts of nitric acid at 30 deg. are poured upon it and boiled for some moments: this second operation, which is intended for taking away all the silver from the gold, is called the reprise. The acid is again decanted with caution, in order to preserve the cornet of gold entire; the cornet which has become very thin and perforated with many holes, is then washed with pure

pure water; it is afterwards made to fall with water, (the matrass being cautiously turned) into the bottom of a small crucible, in order to favour the sliding and falling down of the cornet of gold, along the sides of the matrass, without endangering its breaking; the water is then evacuated, and the metal annealed or heated to slight redness, and it resumes its brilliancy and beautiful colour; it is then weighed with very exact scales, and the quantity of the alloy, and also the standard of the gold, is determined by the weight which it has lost. In order to give a very accurate expression of this standard, the quantity of gold which has been assayed, is divided into decimal parts, and with the aid of very small weights, the slightest loss that has been sustained is known. Some chemists have thought that in the parting assay of gold alloyed with silver, a little gold was dissolved, as seemed to be announced by the deep purple colour of the cornet which remains; but it has been ascertained that this quantity is so small, that it cannot be a matter of interest or alarm in commerce. Several able assayers, especially Cramer, Schindler, and Schlutter, have thought, that the cornet of gold of the parting assay retains a small quantity of silver, which they have called surcharge; Hellot, Macquer, and Tillet, on the contrary, affirm, that it does not contain any sensible quantity of it. M. Sage, however, says, that the gold of the parting assay, dissolved in the nitro-muriatic acid, always precipitates after some hours a small quantity of muriate of silver. In the parting operation, upon the large scale, the same precautions are not taken as in the parting assay, because it is not the exact proportion of the two metals which is wished to be ascertained, but only to obtain the gold refined and pure. We are content with casting the gold alloyed with silver into small portions or grains, and putting it into matrasses with flat bottoms, or even into bottles of stone-ware; then pouring upon it twice or thrice its weight of nitric acid, at 38 or 40 degrees; heating it over a gentle fire; and decanting the liquor when the signs of solution

have

have ceased; that is to say, the motion of effervescence and the disengagement of nitrous gas; then pouring on a new small quantity of acid, which is boiled, upon the residuum; re-commencing this ebullition a third time with a third addition of acid, in order to be certain of carrying off all the silver; washing the gold several times with much water; and lastly, fusing the gold which remains at the bottom of the vessels in the form of powder and of deep purple fragments, in crucibles, in which a little nitre is thrown: this is what is called parted gold. It is in this operation which constitutes the refining of gold, that the pure silver is at the same time prepared, which is also known by the name of parted silver. In order to obtain it, the nitric acid proceeding from the parting, and the waters of the lixiviation of the gold, are poured into dishes of stone-ware; the liquid is diluted with a large quantity of water; a plate of copper is plunged into it, and suffered to remain for forty-eight or sixty hours: the blue liquor, or the solution of copper, which has been formed, is then decanted; the metallic silver deposited by the copper in small crystallized and brilliant grains, is washed with a large quantity of water; it is ignited again, in order to obtain what is improperly termed silver in calx, or it is fused and collected with the aid of nitre, which also purifies it, in order that it may be cast into ingots. The blue liquor, or the nitric solution, which results from this precipitation of the nitrat of silver of parting, is employed in the preparation of verditer, by its mixture with slaked lime: it has been thought that it succeeds better than the simple immediate solution of copper, which has been attributed to a small quantity of silver remaining in it; but this erroneous notion has been confuted by the experiments of Pelletier.

Parting of Gold from Silver, by Cementation.

Parting *by cementation*, which is an appropriate term, is also called parting by concentration, and is usually employed when

when the quantity of gold is so great to that of the silver, as to render it a difficult task by aqua fortis. The mixed metal to be cemented is to be reduced to plates, as thin as small pieces of money. At the bottom of the crucible, or melting pot, is to be laid a stratum of cement, composed of four parts of bricks powdered and sifted, one part of green vitriol, *i. e.* copperas, calcined to redness, and one part of common salt; about the thickness of a finger in depth. Upon this stratum a layer of plates of the metal is to be placed, and then another stratum of cement, and so on till the crucible is filled. It is now to be placed in a furnace, or oven, (after a top has been luted on the crucible) and exposed for twenty-four hours, till it is gradually made red hot, but by no means to be melted. The fire is now left to go out, and the metal is permitted to cool, that it may be separated from the cement, and boiled repeatedly in large quantities of pure water. This gold is afterwards to be tried on a touch-stone; and if it is not sufficiently purified, the process must be formed a second time. By the above method we see how powerfully silver is dissolved by marine acid, when in a state of subtile vapour, which is disengaged from the common salt of the cement. Instead of common salt, nitre may be used, as the nitrous acid readily dissolves silver; but the mixing of common salt and nitre together, is highly injudicious, because the joint acids are able to dissolve some of the gold with the silver. Whatever silver has been separated will now remain in the cement, but it may be freed from this by lead, in the method described in *cupellation.*

Parting of Gold from Silver, in the dry Way.

BESIDES the two former methods of parting, there is a third, which is termed *dry parting,* or parting by fusion, which is performed by means of sulphur. This dry parting is troublesome, and even expensive, and ought not to be undertaken but when the silver far exceeds the gold, because sulphur

sulphur will not separate it so easily as aqua fortis, and will, therefore, require a further application to cupellation and solution.

Before we treat of silver separately, we shall mention the purification of gold by antimony.

Purification of Gold by Antimony.

Gold is purified from its allays by melting it in a crucible that will hold twice its quantity at least, and throwing upon it, whilst in fusion, twice its weight of crude antimony. The crucible is then to be covered, and the whole is to be kept in a melting state for some minutes; and when the surface sparkles, it is quickly to be poured into an inverted cone (see plate 4.) which has been previously heated and greased. By striking the cone on the ground, the descent of the metal will be assisted, and will come out, compactly, when cold, by simply inverting it. The compact mass consists of two substances: the upper part is the sulphur of the crude antimony united with the impure allay; and the lower part is the gold united to some of the regulus of antimony, proportionable to the quantity of metals which have been separated from the gold, and which are now united with the sulphur of the antimony. This regulus of gold may be separated from the regulus of antimony by simple exposure to a less heat than will melt the gold, because antimony is volatile in such a heat, and is then dissipated. If the gold is not sufficiently purified by this first process, (which is often the case) it must be repeated a second and even a third time. When a part is dissipated, more heat is required to keep the gold in fusion; therefore the fire must be encreased towards the end of the operation. The purification is completed by means of a little nitre thrown into the crucible, which effectually calcines the remaining regulus of antimony. Sometimes after these operations, the gold is found to be deprived of much

of

of its usual ductility, which, however, is easily restored to it by fusing it with nitre and borax.

OF SILVER.

Silver, called *Luna* and *Diana*, by the chemists, is a metal of a white colour, and lively brilliancy. It has neither taste nor smell, when perfectly pure. It is less hard than iron, platina, and copper. The form of its crystals are the cube and octahedron; it is also found filiform, in plates, granulas, and in dendrites. When melted silver is suffered to cool very slowly, it forms into dendrites, composed of small octahedrons implanted one in the other, the assemblage of which resembles a pyramid. Silver is, next to gold and platina, the most unalterable of all the metals. The air does not change it, except by very long exposure; but when subject to a strong heat for a great length of time, it becomes oxydated and covered with an olive-coloured scale. It is readily affected by sulphurous vapours and exhalations; and sulphuretted hydrogen gas quickly changes its colour, and transforms it in a short time into a sulphuret of silver. This metal alloyed with gold or copper preserves its white lustre.

Native silver is seldom found pure, but generally mixed with other metals, such as gold, copper, mercury, iron, lead, &c. Lead, indeed, always contains a portion of silver, though in general, the proportion is too small to be worth the expence of separating it. The lead mines in Cardiganshire have afforded great quantities of silver at particular periods; and it is an observation well grounded, that the poorest lead ores are the richest in silver. The situations of gold and silver mines are often diametrically opposite in point of temperature. Gold is commonly found in the hottest parts of the earth, silver in the cold regions. Thus silver is chiefly obtained in Sweden and Norway, and if it occurs in the warm latitudes, it is on the tops of high mountains, that are perpetually covered with snow. Such are mines of Potosi in the

the Andes. The principal silver mine in Europe, is that of Konigsberg, in Norway, to the North of Christiana. That of Potosi yielded in the first ninety years after its discovery about 400,000,000 of pesos, or ounces. The properties of silver which have been enumerated, give it rank next to that of gold, and on that account it has been adopted as a circulating medium, and made one of the first articles of luxury in furniture and ornament. Its specific gravity being about 10.5, is nearly one half less than that of gold. The tenacity of silver is also very considerable, for a wire of this metal, only one-tenth of an inch in diameter, will sustain a weight of two hundred and seventy pounds, without breaking. Although gold exceed it in ductility, yet it may be drawn into wires as fine as hairs, and extended into very thin leaves; so thin, that a grain only may be spread under the hammer, and be made to contain an ounce of water. It is inferior even to copper in hardness and elasticity, and next after it the most sonorous. Under the hammer it acquires a hardness, of which it may be deprived by heating. It seems to be as fixed and indestructible as gold. Kunckel kept silver, as well as gold, in a glass-house furnace during a month, without alteration. All the strong acids are capable of dissolving it, but the muriatic and vitriolic are less powerful than the nitric, or aqua fortis.

Silver may be purified from an alloy with other inferior metals, by treating it with lead, and also with nitre; the former of which methods is termed cupellation or refining, and the latter *purification by nitre*. In the cupellation of silver, a clean piece of the metal, of about a pennyweight and half, is taken and laminated, and then wrapped up in a piece of sheet lead. As the purity of the lead is of the utmost importance, that kind is used which is revived from litharge, in which state it is remarkably pure. To find the proper proportions, the ancient assayers used for this purpose small slips or bars of metal, made with pure silver and copper, in known proportions, in a regularly increasing se-

ries, from the least to the greatest quantity of alloy usually required. These sets of bars were called touch-needles; and, by comparing the silver to be assayed with these needles, in colour, tenacity, and other external marks, its proportion of alloy was guessed at with sufficient accuracy to determine the quantity of lead required in the cupellation. These needles are now, however, almost totally disused in silver-assaying, as an experienced assayer is able to judge of the fineness of silver, with quite sufficient accuracy, by the ease with which it is cut, the colour and grain of the fresh-cut surface, the malleability, the appearances on being heated red-hot, and other tokens. The proportion of alloy (if copper) to the silver being found with sufficient exactness, that of the lead is thus estimated. Copper, when taken by itself, requires from ten to fourteen times its weight of lead for complete scorification on the cupel. But all admixtures of fine metal tend to protect the copper from the action of the litharge, the more, in proportion to the quantity of fine metal. Thus, when one part of copper is mixed with three of silver, no less than 40 parts of lead are required; and one part of copper with 11 of silver require 72 parts of lead. It should be observed, however, that a considerable difference in the respective proportions of lead to copper is observed by different assayers, though the general principle of increasing the lead in proportion to the quantity of fine metal is indisputable. According to Gren (see Vol. II. p. 291. Principles of modern Chemistry),

One part of copper mixed with

30	parts silver requires of lead	128	parts.
15	———————	96	——
7	———————	64	——
4	———————	56	——
3	———————	40	——
1	———————	30	——
$\frac{1}{3}$	———————	20	——
$\frac{1}{15}$	———————	17	——

The

The fire being kindled, and the floor of the muffle sprinkled with chalk, to prevent the cupels from being glued to it in the process, the muffle and empty cupels are first made fully red-hot, and the cylinders of charcoal are put against the open end of the muffle, as already described. The silver and lead are then dropped into the cupel, and the charcoal replaced. The metals immediately melt together; and, when red-hot, the following appearances take place. The melted globule begins to send off dense fumes, which rise to the roof of the muffle, and at the same time a thin stream of red fused matter is seen constantly flowing down the sides of the globule to the surface of the cupel, through which it sinks. This fume is the oxyde of lead evaporated by the heat, and the stream of fused matter is the melted litharge, together with the copper or other alloy of the silver which is thus extracted from it. In proportion to the intensity of the heat are the density of the fume, the violence with which it is given off, and the rapidity with which the melted oxyde circulates, as it is termed, or falls down the sides of the metal. As the cupellation advances, the melted globule becomes rounder, and its surface more streaky, till, in about fifteen or twenty minutes, according to circumstances, all the lead and alloy are vitrified and absorbed by the cupel, the last portions of litharge collect in large bright streaks, which disappear with great rapidity, shewing the melted metal beneath bright, with iridescent colours, which suddenly after becomes opake, and exquisitely white and brilliant, exhibiting the clean surface of pure melted silver. This last appearance is called the lightning of the metal, and it is highly beautiful, as if a red curtain was suddenly withdrawn from the metal. The operation is now finished, and the cupel is drawn forwards to the open side of the muffle, that it may cool gradually before it is removed; for, if it were suddenly fixed, the globule is apt to shoot into an arborescent surface in the act of congealing, by which small particles are thrown out of the cupel and lost, and the assay is spoiled. The management

 of

of the fire in cupellation is of great importance. If it is so intense that the cupel can scarcely be distinguished from the muffle, and the fume of litharge can hardly be discerned through the dazzling heat, not only much of the lead is volatilized to mere waste, but even a portion of the silver is carried off along with it, which renders the assay inaccurate. Even silver alone, and in the greatest purity, may be evaporated by intense heat, as M. Tillet (an ingenious French chemist, and master of the mint at Paris) found, by an experiment, in which a button of pure silver was intensely heated for two hours, and had lost thereby no less than $\frac{1}{20}$ of its weight. If one vessel is inverted over another that contains the silver, in this case the inside of the upper one is found studded with minute globules of silver, when viewed through a common lens. On the other hand, when the fire is too slack in cupellation, the litharge is not fully melted as it forms, and, therefore, is not absorbed by the cupel, but lies on the surface as a red scoria, and the circulation is very sluggish. The proper medium of heat is, when every thing within the muffle is fully red-hot; when the fume of litharge is abundant, and visibly rises to the top, and when the circulation goes on rapidly, and the button continues very globular. Towards the end of the process, the heat should be increased as the button, by the constant abstraction of the lead, becomes constantly less easily fusible.

Purification of Silver by Nitre.

Another method of purifying silver from copper and other admixed base metals, is what is called refining of silver by nitre. The principle upon which this operation is founded consists in the property of nitre to oxydate powerfully all base metals; whereas, on the contrary, the noble metals are not at all affected by it. For as the metallic oxydes and glasses do not remain united with reguline metals, and as these latter

sink

sink to the bottom, when in fusion, on account of their greater specific gravity, they may be easily parted from the scoria. Though, in this way of purification, some loss is always occasioned, it is in other respects easy and expeditious, and deserves particularly to be recommended when a mixture of iron and silver is to be separated.

To effect this, silver previously granulated is mingled with $\frac{1}{4}$ of nitre, $\frac{1}{8}$ of potash, and $\frac{1}{24}$ of glass reduced to impalpable powder. These matters being put in a crucible, covered by luting on another inverted, and having a small hole at its bottom, heat is applied.—When, on holding a red-hot coal over the whole of the upper crucible, no hissing, and no luminous appearance, caused by the detonation of nitre, is perceived, the fire is raised to fuse the silver, which, on breaking the crucible, is found beneath the green alkaline slag.

When it is desired to separate, in the large way, a small quantity of silver from much copper, with which it is alloyed, the process, called eliquation, is resorted to.—This operation is grounded on the nearer affinity of silver with lead than with copper; and, in consequence of which, it fuses and combines with lead at a degree of heat, in which copper continues unfused.—For this purpose black copper (the metal obtained by a second fusion from copper ores), holding silver, is melted with about $2\frac{1}{2}$ parts of lead, and run in moulds, giving it the form of thick round cakes, called eliquation cakes. These cakes are then exposed to a moderate heat in the eliquating-furnace; whereby the lead, being brought to fusion, carries the silver along with it, or eliquates together with the silver. The remaining pieces of copper or eliquated cakes are subjected to a second and stronger fire in particular furnaces to separate as much as possible the lead mixed with silver, which they may still contain. Upon which this copper, eliquated by a second fire, is fused into red or refined copper. And the work-lead is lastly fixed again

again on the cupel to obtain the silver, which by refining is brought to the utmost purity.

We now proceed to detail some of the various methods that are known and practised by workmen in gold and silver, describing first the nature of

Crucibles.

A crucible is a pot generally made of clay, but sometimes of other materials, and intended to bear a strong heat. (For some observations on the quality of these fire-vessels see the article pottery, in another part of this work). The common shape of the earthen-ware crucibles, is either three-cornered or round, and they are fitted with stoppers of the same materials, perforated with a small hole, opening obliquely to allow the escape of any volatile matter, and to prevent any of the fuel from dropping in. As the lower part of the crucible would escape the greatest intensity of heat, and would be liable to crack by the draught of air if it was set directly upon the grate of the furnace, it is usually raised about two inches by a small stand, which may be either solid or hollow. The latter, when inverted, also forms a convenient stand for an earthen retort. The lid of the crucible may be luted on, when necessary, with any kind of fire-lute, particularly with the mixture of borax and clay. It is often of advantage to line the crucible with charcoal, for example, in the reduction of metallic ores that require no flux, such as the black oxyde of manganese. Chemists have usually done this by fitting into the crucible a solid piece of close well-burnt charcoal, and scooping out a hole in the latter; but it is a much more convenient way to mix some powdered charcoal with a very little linseed meal, to moisten it with just so much water as will bring the mixture to a stiff paste, and to line the crucible with it when wet. On applying heat, the linseed meal burns, and gives

out

out a little flame and smoke which escape through the hole of the cover, but this does not derange the charcoal lining. Crucibles are also made of cast-iron, of fine silver, and of platina. The former are sometimes of advantage in analyses where a very strong heat is required to be given to substances in contact with alkaline fluxes, but they are seldom used. Silver crucibles are employed with great utility in the common analysis or resolution of minerals by caustic alkalies; and they are also extremely serviceable in a variety of other experiments, where a heat not exceeding moderate redness is required, and where the substances do not act upon this metal. The use of platina for crucibles has so much increased of late that it is considered as essential to a well-furnished laboratory, and indeed not without reason, as there is no substance that unites so fully the qualities of infusibility at almost any heat, with resistance to the action of almost every chemical reagent. The caustic alkalies, however, have some dissolving power on this metal, as is mentioned under the article Platina. Where a crucible of this metal is used for very high heats, particularly in fires supplied by coal or coak, it should be loosely inclosed in a refractory earthen crucible, otherwise the vitreous slag of the coal is apt to encrust the outside of the platina vessel, and adhere to it with so much force that it can hardly be got off without great violence.

To separate Gold and Silver out of the Sweepings.

Take sweepings; put them into a pan well glazed; add a proportionable quantity of mercury to them; mix the dust and mercury, with your hands, well together, till you think the mercury has extracted all the gold and silver from the dust; then put the mass into a piece of wash-leather, and wring out the mercury; what remains in the leather will be like a paste; put that into an alembic, and drive the mercury

cury from it into a dish with water, which put under the head to receive it; what remains, put to the test; refine it with lead, and separate it with *aqua fortis.*

To separate the Gold from gilt Copper.

TAKE four ounces of sulphur, two ounces of sal-ammoniac, one ounce of nitre, half an ounce of borax; grind them fine, with strong vinegar, to a paste, which lay thin over the gilded copper; give it a gentle heat, until the paste is burned away, and the copper looks black; then take it out, and with a knife, or other such instrument, scrape off the gold in a clean dish, and it will come off very easy.

To separate Copper from Silver, or any other Alloy.

TAKE half an ounce of verditer, or *Spanish green;* white vitriol and sulphur, one ounce of each; alum half an ounce; boil all together in vinegar, in a glass; put in your mixt silver; this will dissolve and extract the copper, and the silver remains whole.

To extract the Silver out of a Ring that is thick gilded, so as the Gold may remain intire: a curious Secret.

TAKE a silver ring that is thick gilt; make a little hole through the gold into the silver; then put the ring into *aqua fortis* in a warm place; it will dissolve the silver, and the gold will remain whole.

To

To make brittle Gold malleable.

PUT gold into a crucible, and give it a brisk fire in a wind furnace, or before the bellows; when the gold is ready to melt, fling gently upon it some good, dry, and clear nitre, which will presently flame, and promote the fusion of the gold, and will spread and cover the gold; then cast it into an ingot, which before has been warmed and anointed with wax.

To make Silver that is brittle, pliable.

TAKE a mark of silver, half an ounce of glass, one ounce of nitre, a quarter of an ounce of borax, half an ounce of *sal gemmæ*, or rock salt; put all this into a crucible, and cover it with a lesser one that has a vent-hole at the bottom, and lute it well; then give it a brisk fire, and continue it till you think the silver is dissolved; then cover the crucible all over with live coals, except the vent-hole, and leave it to cool: take off the upper crucible, and you will find therein hanging all the impurities the silver contained, and which occasioned its hardness: then melt the silver again in a crucible, and throw into it half an ounce of tartar finely ground, and, when in fusion, cast it into an ingot, and you will have fine and malleable silver.

To try whether granulated Silver contains any Gold.

TAKE some silver grains, and make strokes with them on a touch-stone; then, with the end of a feather, let fall a drop or two of *aqua fortis* upon the strokes, and let them continue upon it for a little while; if it contains gold, you will see some remains of the strokes, but if not, the strokes will vanish.

In

In foreign countries, where small works are required to be submitted to the assay of the touch, a variety of needles, already referred to, are necessary. They are not much used here, yet they afford in many cases a considerable share of information. The attentive assayer not only compares the colour of the stroke made upon the touch-stone by the metal under examination, with that produced by the needle, but will likewise attend to the sensation of roughness, dryness, smoothness, and that which the texture of the rubbed metal excites, when abraded by the stone. When two strokes, perfectly alike in colour, are made upon the stone, he may then wet them with aqua-fortis, which will affect them very differently if they are not similar compositions; or the stone itself may be made red-hot by the fire, or by the blow-pipe, in which case the phenomena of oxydation will differ according to the nature and quantity of the alloy.

The brilliancy and fine colour of gold, added to its indestructibility, are too pleasing to the eye, and excite too striking a sentiment of gaiety and pleasure, not to have led men long ago to seek the act, and consequently much to improve it, of extending its appearance, of reducing it almost wholly to surface, and of covering with it a number of substances, which it adorns, enriches, and at the same time defends from every kind of alteration and destruction. Hence, the numerous kinds and varieties of gildings or applications of gold on iron, copper, silver, and other metals, on stones and insoluble salts, on wood and stuffs, on paper and pasteboard. The slightest or most superficial gildings are made with solutions of gold, which are reduced either by a metallic surface, or by phosphorus, burning sulphur, and sulphureous acid. Some of the most simple consist in applying, by means of a mordant, or a glutinous mixture capable of desiccation, leaves of gold, the successive layers of which are more or fewer, which are rendered very smooth by the friction and pressure of hard bodies, and which are made to enter into every cavity, and adapt themselves exactly to every figure, without

without breaking, by means of small instruments, which press them nicely into every hollow. Such is the gilding on wood, pasteboard, tortoise-shell, horn, bone, stones, and a number of substances not of a metallic nature. What is called shell-gold, which is frequently employed for certain gildings, is prepared, as we have seen, by triturating fragments of leaf gold with honey, washing them with water, and afterwards drying the particles of gold that subside. Gold calx is gold in purple oxyde, precipitated from its solution, and diluted with a mucilaginous water, or a solution of gum. To make rag-gold, which is likewise used for some species of gildings, fine old linen rags are dipped in a nitro-muriatic solution of gold, dried, and then burned. When they are used, a wet cork is dipped in the ashes of these rags, and this rubbed on silver, to which the gold in a very attenuated state readily adheres. Sometimes in the gildings in which gold is applied in a brown oxyde, the pieces are passed slightly through the fire, to restore to the metal its purity and brilliancy. The vapour of sulphur, or sulphureous acid, might be employed for the same purpose.

Gilding in *or moulu,* or water gilding, is the most valuable and most solid. It is most frequently applied on copper or brass. The metal to be gilt is first well cleaned by means of sand, and diluted nitric acid. It is dipped into this liquor, and rubbed with a brush of brass wire, of the shape of those used by painters, and called a scratch-brush. It is next put into a nitric solution of quick-silver very much diluted with water, which deposits on the copper a slight layer of metallic quick-silver. The intention of this is to cause the amalgam of gold, which is spread over the metal (previously washed in a large quantity of water to carry off the acid), to acquire a strong adhesion to it. When the amalgam is spread very uniformly over the metal, it is heated, by placing it over a fire, to volatilize all the mercury. The gold remains alone, and of a dull yellow colour. A brilliancy and polish are imparted to it by rubbing it with

what

what is called gilding-wax, or a mixture of red bole (ferruginous argil), verdigris, alum, and sulphate of iron, incorporated with yellow wax, and afterwards heating the work a second time, to burn the wax. The application of gold on silver, a species of gilding in "or moulu," known by the name of vermeil, succeeds still better, and takes a much richer colour, as well as greater solidity, by means of the amalgam, which is simply applied on the silver well cleaned by nitric acid. The silver is then heated in an open fire to expel the mercury. Different tints or shades of yellow, red, purple, or a greenish colour, are given to these valuable and durable gildings by different saline or other matters, which are applied to them in powder, or in a paste, and heated on the amalgam. They are burnished in the usual manner by friction and pressure with hard and polished bodies. Silver gilt, or vermeil, perfectly resembles gold in colour. See Vol. II.

Two of the most industrious and interesting of the arts employed on gold are those of the gold-beater and wire-drawer. These are founded on the extreme ductility of this metal, and the facility with which it may be extended.

Gold-beating consists in striking the metal with a regular and sure stroke, between pieces of the membrane, called gold-beater's skin, on a steel anvil perfectly even, with square hammers, equally smooth and well finished. By repeated strokes the gold is reduced to leaves so thin as to be carried away by the wind. These are then cut into squares, and placed between leaves of soft paper, which is impregnated with red bole in its body. This makes what are called books. The gold leaves are perforated with thousands of holes, so that the light may be seen through them, if held between it and the eye: but, notwithstanding these numerous breaks, their cohesion is still sufficiently great to hold them together in one piece, so that they may be applied whole on the surface of many other bodies.

The

The art of the gold wire-drawer is not less remarkable. A cylinder of silver, covered with a layer of gold, or solidly gilt, is passed and drawn by force through holes made in a piece of steel, from those which are nearly of the diameter of the first cylinder, or differing from it but a little, to those which give almost imperceptible threads, and is constantly elongated in the same state, forming a solid cylinder of silver, covered with a coating of gold, the thinness of which seems to defy the imagination. These gold leaves, and these slender threads of silver gilt, which are commonly called gold wire, serve for a great many uses, in the numerous arts in which they are employed. Among the various employments which gold furnishes to men, the art displayed by the goldsmith and jeweller in giving its plates, its little cylinders, or its wires, all those various and elegant forms in which we see it, is not the least deserving praise. Vessels, utensils, jewels, and trinkets of gold, the fruits of the industry, talents, skill, ability, and invention of these intelligent workmen, are continually enhancing its price an hundred fold; and these articles, in which taste, and the improvement of the fine art of design, display themselves in a superior manner year after year, while they supply perpetual food for that luxury which is happily insatiable, are the beneficial occasion of furnishing many hands with employment, and of promoting among modern nations that commerce which multiplies the enjoyments of man, and is the source of wealth and prosperity to so many countries. Disseminated in thin plates of every shape, or in foils, twisted in curls, drawn out into the form of solid wires, or rolled round threads of silk, which support it and add to its bulk and strength, gold is still further employed on the garments of various individuals, in embroidery, tissues, and laces. Sometimes it denotes the opulence and luxury of those by whom it is worn; at others, it is used as a decoration, and as a mark of dignity among men. It is interwoven with silk, with linen, with woollen, with hair, with feathers; it is combined with colours of every hue; it is

even made to shine through little layers of glass, which soften or moderate its lustre, or project or multiply the brilliant rays reflected by its surface; and it is sufficiently known how much, as an article of dress, it attracts the eye, and seems to command respect, and almost obedience. Accordingly, it always makes a part of the ornaments of superior dignity, in the distinction of rank, among people who admit them; and is employed in festivals, public performances and exhibitions, civil and religious ceremonies; in short on every occasion where it is an object to attract attention, or to produce sentiments of admiration and astonishment, to strike the imagination, and fix the eyes of the multitude. Gold is likewise distinguished by the beautiful colours and rich tints which it communicates to enamels, to paintings on porcelain and earthenware, to coloured glasses, and to imitations of precious stones. Violets, purples, purple-browns, violet, or purple-blues, topaz yellows, and the brilliant and lively reds of the ruby and Syrian garnet, are the chief varieties of tint, which the oxydes of gold, more or less strongly and rapidly heated, or mixed with earths or fluxes of different natures, and in different quantities, produce in all the arts of vitrification.

To amalgamate Gold, or to mix it with Mercury, which is of use to Gilders.

Take a penny-weight of fine gold, beat it into very thin small plates; heat them in a crucible red hot; then take it from the fire, and pour upon them eight penny-weights of pure quicksilver; stir the matter with a little iron rod, and when you see it begin to rise in fumes, which quickly happens, cast your mixture into an earthen pan filled with water, it will coagulate, and become tractable; wash it several times to take away its blackness; thus you have an *amalgam*; from which separate that mercury which is not united, by

by pressing it between your fingers, after you have wrapt it up in a linen cloth.

Amalgam of Gold for Gilding.

If gold be brought in contact with mercury, it is instantly covered with it; and if gold leaf be triturated with mercury, it totally disappears, and is dissolved in the mercury, so that mercury combines with the whole quantity of gold with which it can be alloyed. If the quantity of gold be increased, the amalgam becomes solid. The combination is promoted by heat. The amalgam is of a yellowish white colour, and is fusible in a moderate degree of heat, and crystallizes in the form of quadrangular prisms. It is decomposed by a strong heat, and the mercury is dissipated: hence its use in gilding.

A Method of making Mirrors for Telescopes.

Gold combines with zinc by fusion. The alloy is paler than the gold, has but little malleability; and if the proportion of the zinc be considerable, it is very brittle. An alloy consisting of equal parts of the two metals, is of greater specific gravity than the mean is very hard, susceptible of a fine polish, and is not subject to much alteration from the air. It has been recommended on account of these properties for the fabrication of the mirrors of telescopes.

Alloy for purifying Gold from other Metals.

Lead readily combines with gold by fusion, and the alloy deprives the gold of its ductility, and diminishes the colour. So small a proportion of lead as the $\frac{1}{2000}$th part, destroys the

the ductility of gold. This alloy is made for the purpose of purifying gold from other metals, in consequence of the easy oxydation and vitrification of the lead.

Method of using Gold as a Solder.

WHEN gold is fused it readily adheres to iron; and hence it has been proposed to solder small pieces of steel with gold, which is preferable to the use of copper. Seven parts of gold and one of copper make a good solder.

Method of making an Alloy of Gold for Coin.

GOLD combines with copper by fusion, and on that account the alloy becomes of great importance, because the copper renders the gold very hard, without any injury to the colour. This alloy is said to possess the greatest hardness, without diminishing its ductility, when the proportions are one part of copper and seven of gold. The gold coin of most countries consists of this alloy: but in this kingdom the proportions are eleven of gold to one of copper.

It has been distinctly proved by the experiments made by Mr. Hatchett, and others, that copper and silver are the only metals proper for the alloy of gold coin. All other metals either considerably alter the colour, or diminish the ductility of gold. See Phil. Trans. 1803.

Gilding upon Silver, Brass, Copper, and Iron.

IF you would gild over silver, take the *amalgam* described, and with it rub that which you design to gild, close, every where, that it may receive gold all over; then hold it over a charcoal fire, or lay it upon it, and it will cause the quick-

silver

silver to fly away; after which, you may heighten the colour with gilding wax, as shall be directed.

A particular Secret to gild Silver to the greatest Perfection.

Take *crocus veneris* * and vinegar, add to them quicksilver, heat them together, till they come to the consistence of a paste; with this quicken or anoint the silver you intend to gild, and wherever you quicken, it will turn of a reddish gold colour, which doth not happen when done with quicksilver only, for then it looks white: this is a curious secret; you may gild upon this paste with leaf-gold, which otherwise would require to be ground; it makes the gilding look rich, and of an high colour.

Another advantageous Manner of gilding on Silver.

Take tartar one part, salt two parts; pour water upon them, and add some steel filings: boil the silver therein until it becomes reddish; and it will require only the third part of what gold you would otherwise use.

Gilding after the Grecian *Manner.*

Take sublimated mercury † and sal-ammoniac, of each one ounce; make a solution thereof in *aqua fortis*; then dissolve in it fine gold, beaten very thin; let this solution

* Make slips of copper red-hot, and quench them in urine; repeat this until it easily pulverizes. The powder you will find at the bottom of the urine, which workmen term *Crocus Veneris*.

† Sublimated mercury, or corrosive sublimate, is mercury dissolved by the muriatic acid; and, by fire, raised to the top of a matrass, or other vessel.

 evaporate

evaporate over a fire until it becomes thickish; dip in it a silver wire, and if it comes out black, and, by nealing it in the fire, turns out gilded, it is fit to be used for gilding silver.

The true Italian *gilding.*

Take common vitriol four ounces, alum two ounces, white vitriol one ounce, white lead one ounce, salt two handfuls, river water one quart; let it boil to half the quantity, and let it stand until it settles and looks clear, then it is fit for use.

To boil Silver white.

First neal your silver on a charcoal fire, till it becomes a little reddish: then, having boiled it with an equal quantity of salt and tartar, powdered, with water, for a quarter of an hour, take it out and scratch-brush it in clean water; then take good tartar, tie it up close in a paper, put it in the fire so long until it has done burning and smoking; grind it to a fine powder, mix it with clean water into a paste, and with it rub over your silver: this done, neal it again, and quench it in cold water; brush what remains black upon it with a hair brush; and boil it for two minutes in tartar water; then rince in clean water, and, after you have wiped it with a dry rag, your work will be done.

A Gold Powder.

Take leaf-gold, or any other thin beaten gold, dissolve it in twice its weight of *aqua regia*. Let half the solution evaporate in a sand heat; then take dried linen rags; soak them in the remaining liquid; dry them by a gentle heat; and burn them on a slow fire, in a crucible; the powder will

remain at the bottom, and be of a yellowish colour; and with this the gilding is performed.

Another for Cold Gilding.

TAKE half a pound of *aqua fortis,* put into it two ounces of sal-ammoniac, finely pulverized; let it dissolve over a fire, and then filtrate it through a paper; put it into a matrass, with as much fine beaten gold as will weigh two penny-weights; set it on a slow fire, in order to dissolve the gold into this *aqua regia.* When this is done, add to it two ounces of powdered *sal-gemmæ,* or rock salt, fine and clear, and let it dissolve upon the fire; then take fine clean linen rags, each about a quarter of an ounce in weight; dip them into that liquid, until all the solution is soaked; and having dried them, burn them to a powder, which preserve for use. When you gild any thing with this powder, let the metal you intend to gild be boiled and scraped, that it may be clean and fresh; wet a piece of cork with spittle, or water, and with it take up some of the powder, rubbing the places of the metal you are about to gild, until it is yellow; after which, brush and polish it. You may use, instead of cork a soft leather, sewed or tied to the round end of a little stick. *Or,*

Take of the finest gold the quantity of two penny-weights, and dissolve it in *aqua regia;* add to this solution the weight of the gold of refined nitre; let that also dissolve; this done, dip a fine little linen rag until it has soaked up all; dry it gently, and burn it to powder. With this powder, and fresh water, gild your silver, by rubbing it with a cork, or a leather fastened to the nob end of a stick.

Another Powder to gild with.

TAKE refined gold; beat it very thin; make it into little rolls; fling it into *aqua regia;* put it in a matrass over a slow fire, until all the gold is dissolved, and the solution is turned of a yellow colour; then throw into it some pulverized nitre, by little and little, (as much as it will consume): now take some long narrow slips of old fine linen, draw them through the liquid, and when they are thoroughly wet, hang them in the air to dry, in a glass bowl, or a piece of a broken bottle, and, when dry, light them with a coal, and let them thus, without flaming, consume to ashes. With these ashes you may gild, rubbing it on the silver with a piece of cork. *Or,*

Take a penny-weight of gold, with an equal weight of nitre, and *sal-ammoniac,* all which put into a matrass, with three quarts of *aqua fortis;* then put the gold, nealing hot, into it, and as soon as the gold is dissolved, take some dry linen rags, dip them therein, dry and burn them, by a candle, to tinder, and preserve it for use, as has been said above.

A quickening Water.

TAKE one ounce of quicksilver, and as much *aqua fortis;* let them be put together into a glass, and after the quicksilver is dissolved, add to it five ounces of fresh water; warm it, and it will be fit for use. *Or,*

Take one ounce of *aqua fortis;* put it into a matrass; add to it a quarter of an ounce of mercury, and let it dissolve; then take fresh river water, and mix it with that in the glass, and make it lukewarm: let it stand close shut up, and you will have a good quickening water for gilding.

Another

Another Water-gilding upon Silver.

Take copper-flakes, pour strong vinegar thereon, add to it alum and salt, equal quantities of both; set them on a fire, and when the vinegar is boiled to a fourth part, throw into it what metal you design to gild, and it will acquire a copper colour. If you continue boiling it, it will change into a fine gold colour. This is a fine secret for goldsmiths to gild silver, for the boiling it in that liquid gives the gilding a high and rich colour.

A Water which will give Silver a Gold Colour.

Take sulphur and nitre, of each an equal quantity; grind them together very fine, and put them into an unglazed vessel; cover and lute it well; then set it over a slow fire for twenty-four hours, and what you find remaining, put into a strong crucible, and let it dissolve; then put it into a phial, and whatever silver you anoint with it, will have a gold colour.

A Method to work a Cup, one side Gold and the other Silver.

Take a piece of fine silver; flat it, and file it rough all over on one side; raise with a graver little points upon it. Then take a piece of gold in proportion to what thickness you would have it; form it exactly to the dimensions of the silver, in a flat square; neal both the gold and the silver red hot; then lay them quick on one another, and with a wooden hammer strike them gently together: when thus you have united these two metals, you may make thereof what you please; one side will be silver and the other gold.

To

OF HEIGHTENING THE COLOUR OF GOLD AND GILT WORKS.

Unwrought gold and silver want considerably of that lustre and brightness in which they appear in goldsmiths shops; for there they undergo several operations, and are heightened by gilding wax, colouring and helling; each of which shall be separately explained.

Gilding Wax, used for Gold, or gilded Work.

Take four ounces of clear wax, three quarters of an ounce of verditer, half an ounce of copper flakes, half an ounce of red chalk, quarter of an ounce of alum; melt the wax, and put the other things, finely powdered, into it, and stir it well together; let it cool, and form thereof round sticks like sealing-wax: when you have occasion to make use of it, first heat your gold, and then rub it over with this wax; then neal it, and draw it nimbly through boiling hot water and tartar, and it will give the gold a deep colour.

To give Gold a high Colour.

Take clear wax one pound; crocus of copper an ounce and a half; sal-ammoniac, fine terra-verte and alum, one ounce of each; red chalk, half an ounce and one drachm; crocus martis and tutty, of each half an ounce; nitre, two drachms; mix all these ingredients together, and after you have pulverized them, stir and mix it well with melted wax, which being spread over the gilded work, and then nealed, as has been observed before, it will give the gold a surprising beauty

Nurem-

Nuremberg Gilding-Wax.

TAKE two pound of wax, two pound and one ounce of red chalk, one ounce of vitriol, half an ounce of *æs ustum*, three ounces of verdigrise, and half an ounce of borax.

How to quicken Brass for gilding.

DISSOLVE sal-ammoniac in white-wine vinegar, and with it anoint your work; this will cause it to receive the mercury.

OF SEVERAL GOLD COLOURS, WHEREBY GOLD, OR GILT WORK, AFTER IT HAS BEEN HEIGHTENED WITH GILDING-WAX, RECEIVES ITS PROPER COLOUR.

A Silver Gold-Colour, or a Colour for Gilt Silver.

TAKE one ounce of verdigrise, one ounce of nitre, one ounce of vitriol, half an ounce of sal-ammoniac, half an ounce of borax; grind them fine; boil them in half a pint of urine, to half the quantity; then with a brush dipt in this liquid, brush over your gilt work; put it upon a clear charcoal fire, and when you see it turn black, take it off the fire and quench it in urine.

A Green Gold Colour.

TAKE two ounces of nitre, two ounces of vitriol, two ounces of verdigrise, and one ounce of sal-ammoniac; mix and grind them with vinegar. *Or,*

Take

Take four ounces of verdigrise, four ounces of sal-ammoniac, two ounces of vitriol, two ounces of *æs ustum*, one ounce of nitre; grind them with vinegar, and colour your gold with it.

A French Gold-Colour.

TAKE four ounces of salt, two ounces of alum, two ounces of sal-ammoniac, two ounces of *æs ustum*, one ounce of nitre; grind them with vinegar. *Or,*

Take four ounces of sal-ammoniac, four ounces of verdigrise, two ounces of nitre, one ounce and a half of clean copper-flakes; grind them with vinegar.

A fine Gold-Colour.

TAKE one ounce of verdigrise, one ounce of sal-ammoniac, one ounce of red chalk, one ounce of fine salt; grind all together, and boil them with vinegar. *Or,*

Take one ounce of nitre, one ounce of verdigrise, one ounce of vitriol, one ounce of sal-ammoniac; grind each ingredient, separately, in a clean mortar; then mix and put them in a clean pan, with water, and boil them nearly half an hour.

A Green Gold-Colour.

TAKE four ounces of sal-ammoniac, four ounces of verdigrise, two grains of nitre, and grind them in vinegar.

A White Colour for Gold.

TAKE two ounces of nitre, one ounce of alum, and one ounce of salt; pulverize and mix them well together; then

take

take a piece of a broken crucible; put it in the fire, and let it be red-hot. Wet the work you design to colour, and roll it in the powder; then put it on the red-hot piece of crucible, and the colour will boil up; when it melts, turn the piece of work with your tongs, and when the colour is quite fluid, and is growing yellow, take it out, and lay it upon a clean brick, or anvil, until it is cold. Then take an unglazed pot, or a large crucible; fill it almost with clean water; put into it a handful of salt, and the quantity of a filbert of ground tartar, and six or eight drops of *aqua fortis*; let them boil; then put your work into it, and boil it until the dross of the white colour is taken off; then scratch-brush it.

To colour an old Gold Chain as if it were new.

TAKE urine, and dissolve therein sal-ammoniac; boil the gold chain in this, and it will have a fine colour.

A Green Colour for Gold Chains.

TAKE four ounces of sal-ammoniac, four ounces of verdigrise, one ounce and a half of nitre, half an ounce of white vitriol; make a powder thereof, mix it with vinegar, and boil your chain in it.

A fine Colour for Gold.

TAKE verdigrise, sal-ammoniac, nitre and vitriol, an equal quantity of each; grind them well together; pour vinegar upon them; grind them again, as painters do their colours, and let them dry; then moisten, grind, and dry them again; repeat this for several times; then lay up your powder carefully. When you would colour gold, wet it with urine; rub

it

it with a brush; fling the above powder upon it, and lay it on red hot coals, and it will turn black; then quench it in urine, and rub it with a wire brush: in this manner you may proceed with the other colours.

To make Silver yellow throughout, and to give it the Colour of Gold.

TAKE common *aqua fortis;* dissolve therein as much silver as you please; to eight ounces, take four ounces of *hepatic aloes,* six ounces of turmeric, and two ounces of prepared tutty that has been several times quenched in urine; put these to the solution of the silver; they will dissolve, but rise up in the glass like a spunge, so the glass must be large, to prevent the running over; then draw it off, and you will have ten ounces of silver, which is as yellow as gold.

A Water to give any Metal a Gold Colour.

TAKE fine sulphur, and pulverize it; then boil some stale spring, or rain, water; pour it hot upon the powder, and stir it well together; boil it, and put into it one ounce of dragon's blood; after it is well boiled, take it off and filter it through a fine cloth: put this water into a matrass, after you have put in what you design to colour; close it well, and boil it, and the metal will be of a fine gold colour.

Another Water wherewith one may tinge any Metal of a Gold Colour. A curious Secret.

TAKE *hepatic aloes,* nitre, and *Roman* vitriol, each equal quantities; distil them with water in an alembic, till all the spirits

spirits are extracted; it will at last yield a yellowish water, which will tinge any sort of metal of a gold colour.

To colour Gold.

Take a lock of human hair, of about a finger thick; lay it on live coals, and hold the gold with a pair of tongs over it, to receive the fumes thereof.

To give Gold a fine and high Colour.

Take one ounce of sal-ammoniac, two ounces of copper flakes, one ounce of distilled verdigrise; grind all well together; put the mixture into a matrass; pour upon it one quart of good distilled white wine vinegar: let it thus dry and boil away; then grind it fine, strew it on a glass plate, and set it in a cellar, where it will turn into an oil: this is again to be gently coagulated, and then ground and mixed with sublimated mercury; put half an ounce of it, wrapt up in bees-wax, into the quantity of a pound of gold that is in fusion, and it will give it a high and fine colour.

To give gilded Work a fine Colour.

Take clean salt and sulphur; boil them together, with water, in an egg-shell, after taking away the inside film; take care you do not give too much fire to burn the egg-shell; with this liquid wipe over your gilding, and it will make it of a much brighter colour than it was before.

To brighten Spots in gilding.

TAKE alum; boil it in clear water; put your work into it: this will restore the colour again, and remove the spots.

To give old Silver-Lace, or Trimmings, the Beauty and Colour of new.

TAKE powder of alabaster, or fresh plaster of Paris in powder; put it dry into a pipkin, and let it boil as long as it can; then take it off the fire; when cold, lay your lace upon a cloth, and, with a comb-brush, take up some of that powder, and rub therewith both sides, till it is as bright as you would have it; afterwards polish it with a smooth stone.

To Hell Gold, or Gilt Work.

TAKE two ounces of tartar, two ounces of sulphur, and four ounces of salt; boil this in half water and half urine; dip your gold, or gilt work, into it, and it will give it a fine lustre. *Or,*

Take eight ounces of yellow arsenic, sixteen ounces of sulphur, sixteen ounces of tartar, sixteen ounces of burnt alum, three ounces and a half of salt; boil the mixture in urine and water.

How to take off the Gold from Gilt Silver Tankards or Cups.

To take off the gold from such plate, take sal-ammoniac one part, nitre half a part; grind them both to a powder; wipe over the gilded part with oil; strew the powder upon it,

it, and lay your plate into the fire to heat it well; then take it out; hold your plate over an earthen dish, in one hand, and, with the other, beat it with an iron; the powder will fall into the dish, together with the gold; which you may separate in the manner as has been directed.

Another Method.

Put quicksilver in an earthen dish; heat it lukewarm; in this turn your silver cup, or other utensil, and the gold will separate from the silver, and join the quicksilver; when you see the gold is all come off the plate, take it out and pour the quicksilver with the gold, after it is cold, into another dish; if any place still retains some gold, repeat it, till you perceive no more upon it; then strain the quicksilver through a leather; what remains put into a retort, on hot sand, or ashes, and force the rest of the mercury from it into a receiver with water; what is left, melt together, and refine the gold as has been shewn before.

An approved Method to take off the Gilding from Silver.

Take a glass utensil, put aqua-fortis in it, the quantity whereof must be according to the bigness of your work; take one-eighth of an ounce of sal-ammoniac to one ounce of aqua-fortis; beat your sal-ammoniac fine; put it into the aqua-fortis, and set it over the fire till it grows warm; and when you perceive the sal-ammoniac to work, then put in the gilded silver, and when you observe your work to become of a black colour, then the gold is taken off of it; if there is a pretty large quantity of work, let it lie for half an hour, or an hour, before you take it out, which you must do with a pair of wooden pliers; when it is taken out, put it into clean water; then neal it, and afterwards boil it with tartar; repeat

repeat this three times successively, and your silver will look fresh and new.

How to get the Gold out of Aqua-Fortis.

TAKE a copper bowl, or cup; put into it a glass full of water, and pour in the aqua-fortis which contains gold; then add to it a quarter of an ounce of borax, and boil it up: let it stand all night; in the morning pour it off gently, and the gold will be settled at the bottom: dry it by degrees; and, when dry, put a little borax to it, and melt it.

To give Silver Utensils a Lustre.

DISSOLVE alum in a strong lye; scum it carefully; then mix it up with soap, and wash your silver utensils therewith, with a linen rag.

OF SEVERAL SORTS OF SOLDER FOR GOLD AND SILVER.

THE art of soldering is that of joining together two or more pieces of metal by means of a metallic cement: hence it is absolutely requisite that the solder employed should have the two following qualities, viz. that of being fusible at a lower heat than the metals which it is intended to cement, and of adhering with considerable firmness to their surfaces. The solder for gold is composed of fine gold, with $\frac{1}{4}$ or $\frac{1}{2}$ its weight of fine silver, mixed together accurately by fusion, and afterwards beat out into leaves somewhat thinner than card-paper, and rendered as soft as possible by annealing. It

It is made use of in the following manner: a piece of solder of the proper size and shape being cut off, is laid on the part to be cemented, and sprinkled over with pulverised borax; the flame from a blow-pipe is then applied, and the borax and solder both enter into fusion, the latter incorporating with, and adhering firmly to, the gold: when the juncture is complete, the piece is allowed to cool, and the borax is removed by boiling water, or what is still better a little dilute sulphuric or muriatic acid. The solder will however appear considerably paler than the other part, both on account of the silver with which it is alloyed, and of the borax, which always lowers the colour of gold: this defect may be remedied by melting on the surface of the solder a mixture of two parts of nitre and one of burnt alum, and afterwards washing it off with a soft brush and hot water, by which the natural colour of the gold will be restored, and even heightened. For silver there are two kinds of solder employed, the hard and the soft. The former is composed of equal parts of silver and fine brass; and the latter is prepared by fusing the hard solder with $\frac{1}{16}$th of its weight of pure zinc. The mode of applying it is the same as already directed for gold solder. For copper, brass, and the hard alloys of copper, the best hard solder is composed of brass and zinc, in the proportion of from 8 to 16 of the former to one of the latter, according to the required hardness. The soft solder is composed of three parts of zinc and one of lead, and is applied by means of a common soldering iron, heated red hot. The solder for tin, pewter, and lead, (or the plumber's solder) is of two kinds: the least fusible is composed of equal parts of tin and lead; the more fusible contains, besides, bismuth in various proportions. A very good soft solder is prepared by melting together sixteen parts of tin, eight of lead, and four of bismuth. For delicate works in cut steel the best solder is gold, with a high alloy of copper. For larger works in iron and steel, copper is made use of, or an alloy composed of equal parts of tin and iron.

Filings-

Filings-solder for Silver Chain-Work.

MELT three parts of fine silver, and one part of brass; when in fusion, fling into it a little quantity of yellow arsenic.

A Solder for Silver.

MELT two parts of silver; then put to it one part of thin beaten brass, or tinsel; but do not keep it too long in fusion, lest the brass should fly away in fumes.

Another for Coarse Silver.

FOUR ounces of silver, three ounces of brass, a quarter of an ounce of arsenic; melt them together, and pour them out quick.

Another Silver Solder.

MELT two ounces of silver, one ounce of tinsel; add to them half an ounce of white arsenic; pour it out quick, and it is a very good solder. *Or,*

Melt one ounce of fine silver, and one ounce of thin brass: when both are well melted together, fling one ounce of white arsenic upon it; let it melt, stir it well together, and pour it out quickly.

Of good Solder for Gold.

MELT copper and fine silver together, of each one part; of fine gold, two parts. *Or,*

Take one penny-weight of the same gold your work is of, and allay it with three grains of copper, and three grains of silver.

The

The Manner and Way of Soldering Gold or Silver.

BEAT the solder thin, and cut it into little bits, then take the work which is to be soldered, join it together with fine wire twisted over it; wet the joinings with a pencil with water, mixed up with borax; then lay the bits of solder upon it, and strew some powdered borax over; lay the work, if it be a button or some other small thing, upon a large coal, and blow with your blow-pipe through a large lamp-flame upon it, to melt it.

After this, boil the work either in alum-water, or in *aqua-fortis,* to clear it from the borax; dry it on a charcoal fire; then file or turn it; if it be silver, boil it white in the following manner:

Take the work; lay it on a clear fire, and, when red hot, take it out, and put it by to cool; in the mean while, set a copper-pan, not tinned, with water upon the fire, into which put one part of fine salt, and one part of tartar; boil these together, yet not too fiercely, to prevent its boiling over; after it is well boiled, lay the work, when it is a little cold, into it, and let it boil about six minutes; then take it off the fire, take out the work, and put it immediately into clean water; take it out, and scratch it well with a wire brush, to clear it of the coat; then repeat this work over again; neal it once more; boil it in tartar and salt, and proceed as before; then take black burnt tartar, and mix it with a little water into a paste, with which rub over the work; then neal it on a clear coal fire; take it out, and brush the work well off the burnt tartar in clean water; put it once more in the tartar-water in which it was boiled, and let it boil four minutes; then wash it in cold water, and dry it with a clean rag, and it will be of a white and beautiful pearl colour.

To Solder a Ring set with Stones

TAKE a large charcoal; put two or three penny-weights of silver upon it; melt it with your blow-pipe and the lamp; then, after you have clapped a thin piece of silver solder betwixt the opening of the ring, dip it into it; but as soon as you see the solder run, take off your ring instantly.

A Powder for soldering, equal to Borax.

TAKE the best hard *Venice* soap; scrape it as thin as possible; let it dry, between two papers, in the air; then rub it to a powder; put it into an unglazed pipkin; set it on a gentle coal fire, and let it, by degrees, fumigate until it has no moisture at all. This you may use for all manner of work, and it will do, equal to *Venice* borax.

A Method to make a Metal resembling Gold.

TAKE fine copper filings one pound, fine nitre eight ounces, prepared tutty six ounces, borax six ounces, *hepatic aloes* four ounces; mix all well together, and incorporate the mixture with linseed oil into a mass; put it into a clean crucible, and cover it at top, a finger's height, with pulverised *Venice* glass; lute it well; put it into a wind-furnace; fill the same with dead coals, and then put live coals upon them, *i. e.* light the fire from the top, to go downwards; blow it for an hour, and give it a fierce fire; then let it cool of itself; take out the crucible, and break it, and you will find at the bottom a very fine metal, like gold; this melt again, and add to it one pound two ounces of *sublimate mercury*, and two ounces of prepared tutty, both clapped up in red sealing-

sealing-wax; stir it well with a dry stick; then cast it into a mould, and make of it what you please.

To make Brass.

Brass is an important alloy in the arts, and is a mixture of copper and zinc in various proportions, so intimately united as to form a homogenous malleable yellow metal, applicable to a vast variety of purposes. It is difficult to obtain a perfect union of zinc and copper by mere fusion in open vessels; for at a heat less than is required to melt the copper, the zinc readily takes fire, and burns off before it can mix with the other metal. Accordingly brass has been made by

Cementation.

Place alternate layers of copper in small pieces, with zinc and charcoal, in a covered pot, and continue the fire till the copper is thoroughly impregnated with zinc. The vapour of the zinc, which is a volatile metal, unites with the copper, and the whole runs into brass. A less heat is required in brass making than that which fuses copper, the zinc being able to penetrate the copper when thorougly red hot, and melting it down as soon as it becomes brass.

At Holywell, in Flintshire, the crucibles are charged with mixed zinc ore and charcoal, together with clippings and refuse bits of various kinds: sometimes brass clippings are also used, most of which are previously melted, and run into a small sunk cistern of water, through a kind of cullender, which divides the metal into globules, like shot. Powdered charcoal is put over all, and the crucibles are then covered and luted up with a mixture of clay, or loam, and horse dung.

 From

From forty pounds of copper and sixty of calamine, (ore of zinc), about sixty pounds of brass are obtained. Much of the zinc escapes through the luting, and burns round the crucibles with a beautiful blue flame.

In some parts of the continent the zinc is not furnished by a native calamine, but by the cadmia, or sublimed oxide of zinc. In different countries different proportions of the materials are used.

Receipts for making Brass.

		copper.	cadmia.	charcoal.
At Goslar, in Saxony		30	40 to 45	80 to 90.
	copper.	old brass.	calamine.	charcoal.
At Paris	35	35	40	20 to 25.
	copper.	old brass.	calamine.	charcoal.
In Sweden	30	20 to 30	46	what is sufficient.
		copper.	calamine.	charcoal.
At Stolberg		40	65	130.

Method of making very fine Brass.

VERY fine brass is made by mixing together the oxydes of copper and zinc, and reducing them with a carbonaceous flux. Mix 50 grains of the oxyde of copper, remaining after the distillation of verdigris, with 100 grains of lapis caliminaris, 400 grains of black flux, and 30 grains of charcoal powder: melt the mixture in a crucible till the blue flame is seen no longer round the lid of the crucible; and when cold a fine button of brass is found beneath the scoria, weighing $\frac{1}{6}$th more than the copper alone obtainable from its oxyde without the calamine.

Brass is reckoned a much finer colour, and approaching nearer to that of gold than copper. It is more fusible, less subject to rust, and to be acted upon by the vast variety of substances

substances which corrode copper with so much ease: it is equally malleable when cold, and can be drawn out into thinner wire. Hence sieves of extreme fineness are wove with brass wire, after the manner of cambric weaving, which could not be made with copper.

To Silver Copper, or Brass.

TAKE of fine silver one ounce; sal-gemmæ, *i. e.* rock-salt, and sal-ammoniac of each six ounces; glass-gall six ounces; beat the silver thin, and then put it into one ounce of aqua-fortis; let it dissolve; when dissolved, fling a little salt into it, and the silver will settle like a white powder at the bottom; then pour off that water, and put on fresh; repeat it, until the silver calx has lost all the flavour of the *aqua-fortis;* dry this, then take the above ingredients, and grind them well on a clean stone; when you have well ground them, mix and grind them and the silver calx together, with a little water, until the mixture is like a thick paste; put this up in a clean glass, and when you would silver, take care that your metal be filed and brushed clean; rub it over with the above matter, and lay it on live coals; when it has done smoking, scratch it well, and rub it over again with the silver matter; do this three times successively, and you will have a fine silvering.

To find the Quantity of Silver in an Alloy of Silver and Copper.

COPPER has a much greater affinity with oxygen than silver; consequently the silver is precipitated from its solutions as a fine silver dust by reguline copper. This likewise affords a means to discover what portion of silver may be contained in an alloy of silver and copper. A quantity of the mixture,

mixture, determined by weight, is dissolved in nitric acid; the solution is diluted with water, filtered, and a plate of copper hung in it, till no more precipitate falls down. Then the weight of the precipitate, when edulcorated, is compared with that of the whole alloyed metal put to trial.

This silver-dust, diligently washed and mixed with gum-water, serves as a pigment in water-painting.

What Metals are most proper to incorporate with Silver.

Silver will easily mix and incorporate with fine clean copper, of each an equal quantity: if you add more copper than silver to your composition, it loses the whiteness, and is not fit to make any utensils with. All other metals are of a contrary nature to silver, as lead, tin, iron, brass, &c. therefore they are to be avoided.

To silver Brass, in Fire.

Take calx of fine silver half an ounce, one ounce of sal-ammoniac, three ounces of salt; mix and grind these well together. When you use it, grind and temper it together with water, and rub your brass therewith; neal it brown; then quench it in water wherein tartar has been dissolved; scratch it, and finish your work by polishing it as you see requisite.

A Powder to silver Copper or Brass with, by rubbing it with the Finger or Thumb.

Dissolve a little silver in *aqua-fortis;* add to it as much tartar and sal-ammoniac as to make it like a paste, whereof make little balls; dry and pulverize them: if you take some of

of this powder on your wetted thumb, and rub it upon the copper or brass, it will give it the colour of silver.

A silvering on Copper.

DISSOLVE fine silver in *aqua-fortis;* pour it upon pulverized tartar; and then draw your *aqua-fortis* clear off, and there remains a black matter; with this rub your copper; then neal it well, and boil it in tartar and salt.

How to whiten Silver by boiling.

THE white boiling, as it is called, or the whitening of silver by boiling, is one of the methods of parting copper from silver, in the humid way. For this purpose, silver, wrought in any shape by artists, is first ignited to redness, and afterwards boiled in a lye of muriat of soda, and acidulous tartrite of pot-ash. By so doing, the copper is removed from the surface, and the silver receives a better appearance.

Silvering of copper and brass is done in the same way as gilding. For cold silvering, the copper to be silvered is brushed over with amalgating water steeped into a saturated and diluted solution of silver in nitric acid; then exposed to red heat, and polished. For hot silvering, it is treated with an amalgam of silver and mercury, like copper, to be gilt.

To silver Copper, or Brass, by boiling it.

TAKE three ounces of salt, twenty-six leaves of silver, a quarter of an ounce of tartar, and half an ounce of alum; boil these in an earthen pipkin, and stir well together; put what you design to silver into it; pour water upon it, and

 let

let it boil; after it is well boiled, scratch-brush it; put it in again, and boil it; then scratch it again, and repeat this until it is to your mind.

To boil Brass, like Silver.

TAKE one part of the filings of good pewter; add to it one part of white tartar, and mix together; then take an unglazed pipkin; put these two ingredients, and the brass (which before must be well scratched and cleaned) into it, and let it boil.

To silver Copper, Brass, Steel, or Iron, so as not to come off, except it be made red hot.

TAKE urine, cover it, and let it stand a month; boil it in an earthen pot, skim it, and when the third part is evaporated, take two pints of urine, one ounce of tartar, and an ounce of gall-stone; put it in, and let it boil once up. This liquid keep clean; and if you would silver any metal, take brick-dust on a wet woollen rag, and rub therewith your iron, or other metal, until it is clear and fine, and put it 24 hours in the prepared urine; afterwards dry it, and where you design to silver, rub it over with quicksilver; you must lay it on thin, with an iron spatula which has lain two hours in the urine; then rub it on with a soft woollen rag, and it is a fine bright silvering.

To silver all Sorts of Metals.

TAKE as much *aqua-fortis* as you think there is occasion for; put it in a glass, and set it on hot ashes; then put in

you

your quantity of silver, which first has been beaten very thin, and cut into little shreds. When your silver is dissolved, take it off the ashes, and mix that liquid with as much white tartar as will make it like a paste: if you rub brass, copper, or any other metal, with this, it will be like silver.

Method of Gilding Ribbons, Silk, &c.

Gold has been generally thought susceptible of two degrees of oxydizement, the purple and yellow. These may be reduced by hydrogen gas, or sulphureous acid gas. If white satin ribbon or silk be moistened with a diluted solution of gold, and, while moist, exposed to a current of either of these gases, the metal will immediately be reduced, and the silk become gilt with a regular coat of gold. By this method ornamental figures may be laid on silk, and the gilding will be permanent.

Method of making artificial Topazes.

It has been observed that nitro-muriatic acid, and oxygenized muriatic acid, are the only acid solvents of gold; and the precipitate is called the muriate of gold. A solution of the muriate, being concentrated by evaporation, yields yellow crystals very like topazes.

Method of Gilding the finest Steel.

If ether be added to a solution of the muriate of gold, the gold will leave the acid, and float on the surface, combined with the ether. The ethereal solution has been used by the most eminent artists for defending lancets and surgical instruments from injury by a damp atmosphere.

Method

Method of preparing Shell-Gold.

LEAF-GOLD is to be ground with honey exceedingly fine, then infused in aqua-fortis, and put into shells for use: this is called gold in powder, or shell-gold, and is in considerable repute in miniature painting. For use they dilute it with gum-water.

Method of staining Ivory, Marble, &c.

A SOLUTION of gold in the nitro-muriatic acid will give a beautiful purple-red, which cannot be obliterated, to ivory, marble, and ornamental feathers. It is used also in colouring porcelain. The gold is precipitated by bismuth or zinc. By means of tin the purple-precipitate of Cassius is obtained from the solution, which is in high esteem among the porcelain manufactures.

PART

PART III.

THE ART OF

ENAMELLING IN ORDINARY,

AND THE METHOD OF

PREPARING THE COLOURS.

THE ART OF PAINTING IN ENAMEL.—CHINA ENAMELLING, CURIOUS INSTRUCTIONS HOW TO MAKE ARTIFICIAL PEARLS.—OF DOUBLETS AND FOILS, AND THE MANNER OF COLOURING THEM.—THE ART OF COUNTERFEITING PRECIOUS STONES, WITH OTHER RARE SECRETS.

ENAMELLING is the art of laying enamel upon metals, as gold, silver, copper, &c. and of melting it at the fire, or of making divers curious works in it at a lamp. It signifies also to paint in enamel. Painting in enamel is performed on plates of gold or silver, but most commonly of copper, enamelled with the white enamel; whereon they paint with colours which are melted in the fire, where they take a brightness and lustre like that of glass. This painting excels for its peculiar brightness and vivacity, which are very permanent, the force of its colours not being effaced or sullied with

with time, as in other painting, and continuing always as fresh as when it came out of the workmens' hands. It is usually done in miniature, it being the more difficult the larger it is, by reason of accidents to which it is liable in the operation. Enamelling should only be practised on plates of gold, the other metals being less pure: copper, for instance, scales with the application, and yields fumes; and silver is apt to turn the yellow white. Nor must the plate be made flat; for in such case, the enamel cracks; to avoid which, they usually forge them a little round or oval, and not too thick. The plate being well and evenly forged, they usually begin the operation by laying on a couch of white enamel on both sides, which prevents the metal from swelling and blistering; and this first layer serves for the ground of all the other colours. The plate being thus prepared, they begin by drawing out exactly the subject to be painted with red vitriol, mixed with a certain kind of oil, marking all parts of the design very lightly with a small pencil. After this, the colours, which are to be before ground with water, in a mortar of agate, extremely fine, and mixed with oil somewhat thick, are to be laid on, observing the mixtures and colours that agree to the different parts of the subject; for which it is necessary to understand painting in miniature. But here the workman must be very cautious of the good or bad qualities of the oil he employs to mix his colours with, for it is very subject to adulterations. Great care must likewise be taken, that the least dust imaginable come not to your colours while you are either painting or grinding them; for the least speck, when it is worked up with it, and when the work comes to be put into the reverberatory to be made red-hot, will leave a hole, and so deface the work. When the colours are all laid, the painting must be gently dried over a slow fire to evaporate the oil, and the colours afterwards melted to incorporate them with the enamel, making the plate red-hot in a fire like what the enamellers use. Afterwards that part of the painting must

be

be passed over again which the fire hath any thing effaced, strengthening the shades and colours, and committing it again to the fire, observing the same method as before, which is to be repeated till the work be finished. Most enamelled works are wrought at the fire of a lamp, in which, instead of oil, they put melted grease. The lamp consists of two pieces; in one of which is a kind of oval plate, six inches long, and two high, in which they put the oil and the cotton. The other part, called the box, in which the lamp is inclosed, serves only to receive the oil which boils over by the force of the fire. This lamp, or, where several artists work together, two or three more lamps are placed on a table of proper height. Under the table, about the middle of its height, is a double pair of organ-bellows, which one of the workmen moves up and down with his foot, to quicken the flame of the lamps, which are by this means excited to an incredible degree of vehemence. Grooves made with a gauge in the upper part of the table, and covered with parchment, convey the wind of the bellows to a pipe of glass before each lamp; and that the enamellers may not be incommoded with the heat of the lamp, every pipe is covered at six inches distance with a little tin plate fixed into the table by a wooden handle. When the works do not require a long blast, they only use a glass pipe, into which they blow with their mouth. It is incredible to what a degree of fineness and delicacy the threads of enamel may be drawn at the lamp. Those which are used in making false tufts of feathers are so fine, that they may be wound on the reel like silk or thread. The fictitious jets of all colours, used in embroideries, are also made of enamel; and that with so much art, that every small piece hath its hole to pass the thread through wherewith it is sewed. These holes are made by blowing them into long pieces, which they afterwards cut with a proper tool. It is seldom that the Venetian or Dutch enamels are used alone: they commonly melt them in an iron ladle, with an equal part of glass or crystal; and when the two matters

matters are in perfect fusion, they draw it out into threads of different sizes, according to the nature of the work. They take it out of the ladle while liquid, with two pieces of broken tobacco-pipes, which they extend from each other at arm's length. If the thread is required still longer, then another workman holds one end, and continues to draw it out, while the first holds the enamel to the flame. Those threads, when cold, are cut into what lengths the workman thinks fit, but commonly from 10 to 12 inches: and as they are all round, if they are required to be flat, they must be drawn through a pair of pinchers while yet hot. They have also another iron instrument in form of pinchers, to draw out the enamel by the lamp when it is to be worked and disposed in figures. Lastly, they have glass tubes of various sizes, serving to blow the enamel into various figures, and preserve the necessary vacancies therein; as also to spare the stuff, and form the contours. When the enameller is at work, he sits before the lamp, with his foot on the step that moves on the bellows; and holding in his left hand the work to be enamelled, or the brass or iron wires the figures are to be formed on, he directs with his right the enamel thread, which he holds to the flame with a management and patience equally surprising. There are few things they cannot make or represent with enamel: and some figures are as well finished as if done by the most skilful carvers.

Enamels are vitrifiable substances, and may be arranged into three classes, viz. transparent, semi-transparent, and opaque. The two former are chiefly employed in enamelling on gold and silver, for watch-cases, trinkets, and other small articles of jewellery; the latter is principally used on copper, for the making of clock and watch-dial plates, and for other plates, which, when properly fluxed, are fit for the purpose of enamel-painting. The basis of all kinds of enamel is a perfectly transparent and fusible glass, which is rendered either semi-transparent or opaque, by the admixture of metallic oxyds. White enamels are composed by melting

oxyde

oxyde of tin with the glass, and adding a small quantity of manganese, to increase the brilliancy of the colour. The addition of oxyde of lead, or antimony, produces a yellow enamel; and Kunckel affirms, that a beautiful yellow may be obtained from silver. Reds are formed by an intermixture of the oxydes of gold and iron; that composed by the former being the most beautiful and permanent. Greens, violets, and blues, are procured from the oxydes of copper, cobalt, and iron; and these, when intermixed in different proportions, afford a great variety of intermediate colours. Sometimes the oxydes are mixed before they are united to the vitreous bases. Such are the principal ingredients employed in the production of the various enamels; but the proportions in which they are used, as well as the degree and continuance of the heat necessary to their perfection, constitute the secrets of the art. Other substances than those here mentioned are occasionally used in the composition of enamels; and it has been said, that the peculiar quality of the best kinds of hard or Venetian enamel is owing to the admixture of a particular substance found on mount Vesuvius, and known to be thrown up by that volcano.

The processes of enamelling have never been accurately described. The jealousies that exist in all arts in which any thing like a scientific knowledge is required, operate to seclusion. The practitioner conceals his information from motives of profit, and the amateur seldom acquires an insight sufficiently minute to enable him to unfold the modes of operation. Enamelling is usually divided into dial-plate enamelling and transparent enamelling: the former includes the manufacture of clock and watch plates, and things of the same kind: the latter comprehends the enamelling of watch-cases, and trinkets of all kinds.

Dial-plate enamelling consists of the two divisions of hard enamelling and soft, or glass-enamelling: in the first branch the Venetian enamels only are employed; in the last, the English, or glass-enamels. The practice of hard enamelling requires

requires more skill, time, and labour than the others, and is consequently esteemed the most. In preparing the metals to be enamelled on, whether of gold, silver, or copper, the process is similar; one description will therefore suffice for the whole:—and first of the making of watch-dials. The copper being evenly flatted in long slips (which is done at the flatting mills between steel rollers) and to a proper thickness, pieces are cut off for use according to the size wanted. They are then annealed in a clear fire, in order to make them sufficiently pliable to take the required forms which is given to them by means of dies. According to the kind of watch to which the dial is to be applied, the copper, if for a second's watch, must be kept almost flat; or if for a watch where a greater space is wanting beneath, to give more scope for the wheels, must be raised from the edge to the centre in a regular and exact manner. To effect this, a small circular block, or setting die, is used, made of box or other hard wood, turned out to the necessary degree of concavity, and having a hole in the middle to receive the eye of the copper when placed within the hollow of the block. The copper is then gradually set up to the convexity or height required, by rubbing it gently, yet firmly, with a bent, or setting spatula, formed of a thin slip of steel about five inches long, properly fixed.

The coppers being thus prepared, the next process is that of enamelling, properly so called. The enamel, as it comes from the makers, is generally in small cakes from four to five or six inches in diameter. In preparing it for use, a small hammer is used, having one end flat, and the other of the shape commonly employed to rivet with. With this the enamel is broken into thin pieces or flakes, by striking the edge of the cake smartly as it rests upon the fore finger of the left hand. The pieces are then put into an agate mortar, and with a pestle of the same kind are finely pulverized, the splinters being prevented from flying about, by keeping the enamel covered with pure water all the time the process

of grinding is going on. The point at which the trituration should be discontinued, can only be ascertained from experience, as the different kinds of enamel, and the different modes of its application, require the ground enamel to be either more or less fine. In general it may be stated, that the backing should be much finer than the first coat; the second coat of an intermediate fineness; the hard enamels considerably finer than the glass, and the flux still finer than those, as the fire operates with less effect upon the flux than upon either of the former substances. In grinding, great care must be taken to keep the enamel free from dirt, and the light flue which arises must be washed away three, four, or more times, as may be necessary in the course of the operation, till the water comes off quite clear. When the enamel is ground, the coppers having been first cleansed, and carefully brushed out with water, are spread, face downwards, over a soft half-worn cloth, or smooth napkin, and a thin layer of hard enamel, called, in its ground state, the backing, is spread over the under sides with the end of a quill, properly cut, or with a small bone spoon. The coppers are then slightly pressed on by another soft cloth or napkin, which, by imbibing some portion of the water, renders the enamel sufficiently dry to be smoothly and evenly spread with the rounded side of a steel spatula. The water is then again dried out by the napkin, and a yet further evenness produced by going over the enamel as before, with the spatula; and these operations are repeated till the back becomes completely smooth, and the enamel is of an equal thickness all over. It must be observed, that the water should not be entirely absorbed, as in that case the enamel would fall off, in powder, before the subsequent operations are completed. When the enamel is properly spread, the loose particles are carefully cleared away from the edge and eye of the coppers; from the former by the spatula, from the latter by twisting round it the pointed end of a quill, and the process of laying the bottoms is thus finished. The next operation is to lay

the first coats; that is, to spread a layer of glass enamel over the upper sides of the coppers. In doing this, the surface is first brushed slightly over with a small camel-hair brush, or a hare's foot, to remove any dirt or extraneous particles of enamel, as the mixture of any hard enamel with the glass would infallibly spoil the work. The glass is then spread upon the coppers in a layer, the thickness of which is commonly the same as the height of the edge and eye. The water is afterwards slightly absorbed with a clean napkin smoothly folded, and the enamel spread by a thin, flat spatula, till all unevenness is removed, and the surface lies regularly from edge to centre. The edge being then gently tapped twice or thrice at different places with the spatula, the water rises towards the top, and is again dried off by the napkin, when the enamel is once more made smooth by the spatula, and the water being wholly taken up by the napkin, or as nearly so as can be effected, without disturbing the enamel, the first coats are placed upon rings for firing.

The first coats having been placed carefully upon the rings, are next put into a shallow tin vessel, called a tin cover, which is either made square or round, according to the fancy of the artificer, and is commonly about three quarters of an inch in depth. All the moisture is then slowly evaporated from the enamel, by placing the cover upon a German stove, or in some other convenient situation near a fire, where the evaporation can be properly regulated: for should the water be dried off too quickly, the work would be in danger of spoiling from blisters. These are very small air-bubbles, which, by rising to the surface of the dial-plates, destroy their smoothness and beauty. They appear to be occasioned, partly by want of due care in laying on the enamel, and partly by the confinement of the air which the water contained, and which, in the process of firing, becomes rarefied; throwing off, by its expansion, a portion of the surrounding enamel, yet not entirely escaping without a very vivid heat, and even then resolving into black or green specks,

so

so coloured through the oxydation of the copper. The firing is executed beneath a muffle, placed in a reverberatory furnace, ignited with coke or charcoal. See Plate IV. When your reverberatory is building, let the mouth part of the muffle be placed fronting the mouth of the furnace, and be fixed in such a manner that the furnace fire may not play into it, nor the ashes drop upon your work.

Your furnace may be either round or square; it may be of iron or earth, no matter which; only let there be so much room in the inside as will contain the muffle, with a good charcoal fire round about to cover it: you must have a slice, or iron plate, to put your work upon, which, with a pair of tongs, convey into the furnace, and bring out again.

The heat is to be regulated, and in a short time the enamel melts or runs; and becoming consolidated, the first coat is complete. There will probably be a considerable depression in the enamel of the first coats by the act of fusion, which deficiency will be supplied by the second coat. Great attention must be paid to the management of the fire, the knowledge of which can only be attained by practice. When the second coat is on, it is fit for polishing, a term which implies brightness and evenness. The materials used in polishing glass plates are grey-stones, rag-stones, called also burrs, fine ground silver sand, and water, which are used in the order here put down. When sufficiently polished, the plates are to be clean washed, and the specks of dirt picked out with a sharp graver. They are then well rubbed over with some fine ground glass, to remove the stains that may be left by the polishing stones.

The operations of transparent enamelling are nearly similar to what have been already described in the making of watch-dials; but as the work is generally of a more minute kind, greater attention is required in its several parts. Watch-cases are commonly enamelled on gold, as well as almost all superior articles of the fancy kind, and frequently the surface of the gold is engraved into different figures before the enamel

is laid on. When enamels of different colours, as blue, red, &c. are to be employed on the same article, small edges or prominent lines are left in the substance of the metal for the purpose of keeping the enamels separate, and these are polished with the enamel, and reduced with it to a similar equality of surface. In ornamental transparent work a good effect is often produced by applying small thin pieces of gold and silver, cut or stamped, into different figures, upon the surface of the first coating of enamel, where they are fixed with fire, and then covered with a second layer, through which they appear with much beauty.

In choosing enamels for use, great experience is necessary: indeed the most expert practitioner may be deceived, unless he make the requisite trials, by aid of the furnace. Some enamels can only be employed alone; others may be used for the upper coats, but require a stronger kind for the backs; and some can be used only for backing. Should a new sort be proffered for use, experiment alone is the criterion by which its qualities can be determined. In a similar manner, some fluxes will only agree with particular enamels; others must be used separately; and others again must be mixed in grinding, before they can be employed with certainty. In every branch of enamelling, it is essential that the copper, or other metal employed to enamel on, should be of a proper thickness. Should the metal be too thick, the plates will always crack, either in their second coats, or in their polished state; and should it be too thin, they would be extremely likely to warp from the too powerful action of the enamel. The due medium can only be ascertained by practice.

It is sometimes desirable to take off the enamel from trinkets without injuring the metallic part. To effect this it is recommended to lay a mixture of common salt, nitre, and alum in powder, upon the enamel required to be removed; and afterwards to put it into the furnace; and when the fusion has commenced to throw the case, &c. suddenly into water, which causes the enamel to fly off in flakes.

We

We shall now proceed to the most approved recipes.

To prepare the Flux for Enamel-Colours.

TAKE four ounces of red lead, and one ounce of well washed and clean sea sand; melt them together, and put them in a cold ingot.

Another Sort of Flux, which is very soft.

TAKE one ounce of white lead, a quarter of an ounce of red lead, twelve grains of pebble; heat the pebbles red hot, and quench them in urine; repeat this until you can crumble them to an impalpable powder between your fingers; then beat them fine; put them with the ingredients into a clean crucible; lute it well, and when dry, give it a fierce fire for half an hour, or longer; then take it off the fire, and let it cool of itself; break the crucible, and melt the contents again in another clean crucible, and pour it into a clean ingot, or a bright brass weight-scale, and then it will be fit for use; beat and grind it in a mortar of Wedgwood's ware, to an impalpable powder. When you mix your colours therewith, temper as much as you have occasion for with oil of spike, *i. e.* spike-lavender.

A Green Colour.—A *green colour* is best made by *mixing blue and yellow* together, and by adding a little brown, if it be required to be dark. The reason is, that greens are otherwise made from copper, which must retain some portion of the acid in which it was dissolved if it remain green; and if you dissipate all the acid it becomes dusky, which will happen on exposing the enamel to fire.

Take copper, and dissolve it in *aqua-fortis*; then evaporate. Take of this one part, and three parts of flux. *Or,*

Take

Take a copper plate, and with a piece of pumice-stone and water, rub it over; receive the water into a bason or dish, and let it settle; pour off the water, and neal the settling; then take thereof one part, and three parts of flux; and this makes a good and fine green.

Dark Green.—Take green enamel two parts, yellow smalt one-eighth part, and six parts of verditer.

Yellow Colour.—Take fine king's yellow, and neal it in a crucible; one part yellow, and three parts flux.

A high Yellow.—Take gold-yellow enamel, vitriol and flux; grind and temper them to your mind with oil of spike.

Brimstone Colour.—Take calcined *Naples*-yellow one part, three parts of burned lead-yellow, and three parts of flux.

A Black Colour.—Take manganese; neal it upon a tile; the blacker it comes off the fire the better; take one part thereof with three parts of flux, ground with oil of spike.

A good Red.—Take green vitriol; grind it fine, and dry it in the sun; then neal it between two crucibles, well luted, so as to prevent the air's coming to it. Take thereof one part, and two parts and a half of flux; melt them together, and when you use them, grind them with oil of spike.

Blue Colours.—Take fine smalt; wash it well with clean water, as fine as possible; put a little flux to it, and grind it with oil of spike. *Or,*

Take ultramarine one part, flux four parts; grind them with oil of spike.

Purple Colour.—Take one part crocus martis, one part smalt, and three parts flux. *Or,*

Take blood-stone, and grind it with vinegar; when it is fine, wash it clean, and burn it over a candle on a thin plate.

Hair Colour.—Take umber, and neal it in a crucible; then take one part thereof, and three parts of flux; grind them with oil of spike.

Fawn

Fawn Colour.—Take vitriol, glow it as hot as possibly you can, *i. e.* give it a red heat; then take of it one part, and three parts flux.

Carnation Colour.—Take yellow ochre, and glow it in a crucible very hot; after that let it cool, and beat it in an iron mortar, and, if it is not of a fine colour, neal it again; take of this one part, and three parts and a half of flux.

A steel Red for Enamel.—Take fine thin beaten plates of steel, and cut them into small shreds; put them into a vial with *aqua-fortis*, and when reduced over a slow fire, neal it; of this take one part, and three parts of flux.

To prepare the principal Matter *for Enamel Colours.*

TAKE lead fifteen pounds, plate-tin ashes sixteen pounds; mix and calcine these, as directed in the first part; after you have calcined your lead and tin, search out the calx, and put it into an earthen pot filled with water; set it over a fire, and let it boil a little; after which, take it off, and pour the water into another vessel, which will carry the more subtil calx along with it: repeat this till you can subtilize no more of the calx, and the water comes off clean without any mixture. What gross part remains in the pot, calcine as before, and this repeat till you can draw off no more of the subtil matter. Then pour the water from all your receivers into one that is larger, and evaporate it on a *slow* fire.

Of this calx take 12 pounds; frit of white sand, beaten and sifted, 12 pounds; nitre purified 12 pounds; salt of tartar purified two ounces. Put these powders all together into a pot, place it in a glass-house furnace for ten or twelve hours to digest and purify. Then take and reduce it to an impalpable powder, and keep it in a close, dry place for use. Thus is your first or *principal matter* for enamel colours prepared.

To make Enamel of a Milk-white Colour.—Take three pounds of the fore-mentioned *principal matter,* twenty-four grains of prepared magnesia, and arsenic two pounds; put these together into a melting-pot, to melt and purify over a fierce fire; when the matter is melted, throw it out of the pot into fair water; and having afterwards dried it, melt it again as before; do this for the third time, changing the water; when you have thus purified it, and found the white colour answer your intent, it is done; but in case it has still a greenish hue, add a little more magnesia, and, by melting it over again, it will become as white as milk, and be fit to enamel with on gold or other metals: take it off the fire; make it into cakes, and preserve it for use.

A Turcoise Blue Enamel.—Take of the principal matter three pounds; melt and purify it in a proper melting-pot, then cast it into water; when dry, put it again into a pot, and being melted over again, add to it at four times this composition: scales, thrice calcined *, two ounces and a half; prepared zaffre forty-three grains; prepared magnesia twenty-four grains; stone-blue two ounces; mix and reduce these to a very fine powder; stir the matter very well with an iron rod, for the powders to incorporate. When your matter is thus tinged, observe well whether your colour answer your intention before you empty the pot: if you perceive the tinging powders are too predominant, add more of the principal powder; and if too faint, add more of the tinging powders. Your own judgment must direct you in the management of this preparation.

* To calcine copper scales, such as come from the hammer of braziers or copper-smiths: wash them from their foulness, put them into a crucible; place it in the mouth of a reverberatory furnace, for four days; after which, let them cool; then pound, grind, and sift them. Put this powder a second time into the furnace, to reverberate four days longer; proceed as before; and after it has stood again the third time for four days, reduce it into powder, and it will be fit for the use intended.

A fine

A fine Blue Enamel.—Take two pounds of the principal matter; one ounce of prepared zaffre, or of indigo blue; twenty-two grains of copper, thrice calcined; mix and reduce these to a fine powder, and put them into a melting pot: when the metal is melted, cast it into water; then dry it and put it into the pot again; let it stand upon the fire until it is well incorporated; take it off; make it into cakes, and keep it for use.

A Green Enamel.—Take two pounds of the principal matter, one ounce of copper scales, thrice calcined, twenty-four grains of scales of iron, blue vitriol two ounces, yellow arsenic one ounce; mix and reduce these to an impalpable powder, and, at three several times, or in three several portions, fling it into the principal matter, stirring the metal so as to tinge it equally. When the colour is to your liking, let it stand for a while in the fire, to incorporate thoroughly; then take it off, and you will have a delicate green. *Or,*

Take * Feretto of *Spain* two ounces, forty-eight grains of crocus martis, yellow arsenic two ounces; pulverize and mix these well, and put them into a white-glazed pot †; set it in the furnace to melt, and refine the matter; after which cast it into water; and when dried, throw it again into the pot: when melted, observe whether the colour is to your liking; if so, let it stand for some time longer to refine. If you find the colour too faint, add more of the tinging powder.

* Feretto of *Spain* is thus prepared: stratify thin plates of copper with vitriol, in a crucible; put it in the mouth of a glass furnace for three days; then take it out, and add to the copper fresh layers of vitriol, stratifying them as before: now put the crucible in the same place of the furnace; repeat it six times successively, and you will have an excellent feretto. Beat this to powder, and it will tinge glass of an extraordinary beautiful colour.

† The best melting-pots for glasses and fluxes are made of tobacco-pipe clay. They may be had of Messrs. Pugh and Speck, melting-pot manufactory, bottom of Booth-street, Spital-Fields; also of Mr. Knight, ironmonger, Foster-lane, Cheapside.

A Black Enamel.—Take of the principal matter two pounds, prepared zaffre one ounce, and prepared manganese one ounce; pulverize and mix these, and proceed as directed in the preceding colours.

A Velvet-black Enamel.—Of the principal matter two pounds, red tartar two ounces, prepared manganese one ounce; pulverize these, and put them into a glazed pot, bigger than ordinary, because the matter will rise; for the rest, proceed as directed before.

A Purple-colour Enamel.—Of the principal matter two pounds, prepared manganese one ounce, indigo blue half an ounce; proceed as above.

A Violet Enamel.—Of the principal matter three pounds, prepared manganese one ounce, thrice calcined copper scales twenty-four grains, terra verte one ounce; pulverize and mix these all together, and proceed as before directed.

A Yellow Enamel.—Of the principal matter three pounds, tartar one ounce and a half, prepared manganese six grains, yellow orpiment two ounces, arsenic one ounce; pulverize them, and proceed as before directed.

An excellent Red Enamel, of a very splendid ruby Colour.—This enamel is of a surprising beauty, and its lustre equals that of a red ruby. To prepare this, take equal quantities of manganese and nitre; let them reverberate and calcine in a crucible in a furnace for twenty-four hours; take it then off, and wash it well in warm water, to separate the nitre; dry it well, and the mass will be of a red colour: to this add an equal quantity of sal-ammoniac; grind this on a marble with distilled vinegar, as painters do their colours; dry it, and pulverize it; then put it into a strong matrass, and let it sublimate for twelve hours; break off the neck of your matrass, and mix all the volatile and fixed parts together, adding the same quantity of sal-ammoniac as there are flowers, and take care to weigh them before the composition; grind, pulverize, and sublimate as before, repeating this until your manganese remains fusible at the bottom of the matrass: this

this preserve to tinge your crystal with; and according to your liking, add either a greater or less quantity of the manganese, or of the crystal, until you have brought it to its degree of perfection.

A Rose Colour Enamel.—Take five pounds of ground crystal *; melt it in a crucible; add, at four different times, two ounces and a half of thrice calcined copper; stir the metal every time; then pour into it crocus martis and manganese prepared as directed; let it stand for six hours to cleanse, and if the colour is too light, add a little more crocus martis, until it be of a fine rose colour.

Observe that all the colours, (which are not pure enamel), must be incorporated with the crystal, that they may vitrify the better, which else they would not easily do. Some workmen make use of rocaille; but that does not answer the purpose so well as ground crystal.

A fine Purple.—Take half an ounce of fine gold; neal it, and beat it into very thin plates; dissolve this in four ounces of aqua regia; put it into a glass cucurbit, and set it on warm ashes, or sand, to dissolve; put in it a small matter of nitre; when all is dissolved, drop two or three drops of oil of tartar into it, and stop the cucurbit close, to prevent its boiling over: then put in some more drops of oil, and repeat this until it hisses no more. After this put some lukewarm rainwater to it, and let it stand for some time, and a powder will settle at the bottom of the cucurbit; then pour off the water leisurely into an earthen, or glazed receiver; put more fresh water to the sediment, and repeat this until the water comes

* *Crystal* means crystal glass, which is usually kept in powder, fit for use by enamellers; it may be thus made: take one ounce of pure quartz make it red hot in a crucible, quench it afterwards in water, and repeat the operation till it be sufficiently soft to admit of being triturated: levigate it finely, and mingle it accurately with half an ounce of salt of tartar, three drams of calcined borax, one dram and a half of flake white, and a scruple of nitre. Put this powder into an assaying crucible luted and gradually heated. When the frit has been one hour in fusion, let it cool by degrees, break the crucible, and take off the clear glass.

off

off clear, and free from the sharpness of the aqua regia. When the powder is settled, and all the water poured from it, then put it upon a piece of whited brown paper, to separate it from the rest of the water; and dry it on a warm tile, or in the sun. To one part of this powder, add six parts of the principal matter; grind it with oil of spike, and it will make a good purple.

A good Red Enamel Colour.—Take green vitriol; put it into a copper cup; hold it over a fire, and stir it with a copper wire until it is reduced to a powder; burn this upon a hot tile, on which let it cool of itself; then wash it with rain water, and when settled, pour off that, and put fresh water on, and thus repeat it several times.

A Flux for Red Enamel.—Take of red lead four ounces, white scouring sand one ounce; melt it, and pour it into an iron mortar.

Some General Observations.

Before we proceed to another subject, we will conclude this article with a few observations and general rules, for the more easy apprehending of what has been said already.

Observe that gold is the most proper metal to enamel upon; that every colour, except a violet or purple, receives an additional beauty from it, to what it does from silver or copper: that it is best to enrich gold with such beautiful colours, since they raise admiration in the beholder when the skilful artist places them in due order.

The ancients only painted in black and white, with something of a carnation, or flesh colour; in process of time they indeed made some few improvements, but all their enamel colours were equally alike on gold, silver, or copper, every one transparent; and every colour wrought by itself. But since the modern artists have found out a way of enamelling with opaque colours, and of compounding them in such a manner as to shade or heighten the painting in the same

manner

manner as is done in miniature, or oil painting, this art has gained the pre-eminence in small portraits, having the advantage of a natural and lasting lustre, which is never tarnished, nor subject to decay.

The purple coloured enamel does best on silver, from which it receives great beauty; so does the ultramarine, azure, and green; all other colours, as well clear as opaque, do not suit it; copper suits with all thick enamels, but is unfit for that which is clear.

Make choice of good, hard, and lasting enamel: the soft is commonly full of lead, which is apt to change the colours and make them look sullied and foul; but if you follow the prescriptions, you will meet with no such inconvenience.

Remember, when you lay white enamel on gold, silver, or copper, to dilute it with water of quince-kernels, as has been directed: clean enamel colours, mix only with fair water; and the opaque, when mixed with flux, or the principal matter, dilute with oil of spike.

Be careful not to keep your work too long in the furnace, but take it often out, to see when it has the proper glazing; and then it is finished.

Before you use your enamels, grind as much as you have occasion for, with fair water, in an agate mortar; thus do with all your clear and transparent enamels, and by this means you will have all things in readiness to proceed in your work with pleasure.

All opaque colours that will stand the fire, are fit to be used in painting enamel. The ingenious artist will not be at a loss, but will meet probably with several colours not yet discovered, as frequently happens to those who try experiments.

In the year 1805 Mr. Samuel Annes obtained a patent for methods of preparing various enamel colours, and of applying the same to the ornamenting useful vessels of glass. His particular object, in the composition of the said colours, beside their respective tints, was to render them so fusible

as to melt or adhere to vessels of glass by a degree of heat not so considerable as to melt or injure the vessels themselves. We shall give here an account of his most approved methods.

To prepare the Flux or principal Matter for Enamelling on Glass Vessels.—Take one pound of saturnus glorificatus (to prepare glorificatus thus: take litharge or white lead, put it in a pan, pour on distilled vinegar, stirring it well over a gentle fire till the vinegar becomes impregnated with the salt of the lead, evaporate half vinegar, put it in a cool place to crystallize, and keep the crystals dry for use); half a pound of natural crystal calcined to a whiteness; one pound of salt of polverine, or other fit alkali; mix them together, and bake in a slow heat for about twelve hours, then melt the mass, and pulverize the same in an agate mortar, or any other proper vessel which is not capable of communicating any metallic or other impurity.

To make Green.—Take one ounce of copper dust, two ounces of sand, one ounce of litharge, half an ounce of nitre; or two of copper, one of sand, two of litharge, one and a half of nitre; mix them with equal parts of flux, or vary the proportions of them, as may be found necessary, according to the tint of colour required.

To make Black.—Take calcined iron one ounce, cobalt, crude or prepared, one ounce, or zaffer two ounces, and manganese one ounce; mixed with equal parts of flux, by melting or grinding together.

To make Yellow.—Take of lead and tin ashes one ounce, litharge one ounce, antimony one ounce, sand one ounce, nitre four ounces; calcine or melt them together, pulverize, and mix them with a due proportion of flux, as the nature of the glass may require; or take more or less of any or all the above, according to the depth of colour desired.

To make Blue.—Take prepared cobalt one ounce, sand one ounce, red lead one ounce, nitre one ounce, flint glass two ounces; melted together by fire, pulverized and fluxed according

according to the degree of softness or strength of colour required.

To make Olive.—Take one ounce of the blue as prepared above, half an ounce of black, half an ounce of yellow; grind them for use; if necessary, add flux to make it softer.

To make White.—Take tin prepared by aqua-fortis one ounce, red lead one ounce, of white pebble-stone or natural crystal two ounces, nitre one ounce, arsenic one drachm, with equal parts of flux, or more or less as the softness or opacity may require; melted, calcined, or used raw.

To make Purple.—Take the finest gold, dissolve it in aqua-regia, regulated with sal ammoniac; put it in a sand heat for about forty-eight hours to digest the gold, collect the powder, grind it with six times its weight of sulphur, put it into a crucible on the fire till the sulphur is evaporated, then amalgamate the powder with twice its weight of mercury, put it into a mortar or other vessel, and rub it together for about six hours, with a small quantity of water in the mortar, which change frequently, evaporate the remaining mercury in a crucible, and add to the powder ten times its weight of flux, or more or less as the hardness or softness of the colour may require.

To make Rose Colour.—Take purple as prepared above, mix it with thirty times its weight of flux, and one hundredth part of its weight of silver leaf, or any preparation of silver, or vary the proportion of the flux and silver, as the quality of the colour may require; or any of the other preparations for purple will do, varying the proportion of the flux and silver as above; or any materials, from which purple can be produced, will, with the addition of silver and flux, answer.

To make Brown.—Take red lead one ounce, calcined iron one ounce, antimony two ounces, litharge two ounces, zaffer one ounce, sand two ounces, calcined, or melted together, or used raw, as may be most expedient, or vary the proportions of any or all the above as tint or quality may require.

Method

Method of application.—The aforesaid colours may be applied to vessels of glass in the following manner: viz. by painting, printing, or transferring, dipping, floating, and grounding.

To paint, mix the colours (when reduced by grinding to a fine powder) with spirits of turpentine, temper them with thick oil of turpentine, and apply them with camel hair pencils, or any other thing thought proper; or mix them with nut or spike oil, or any other essential or volatile oil, or with water, in which case use gum arabic, or any other gum that will dissolve in water, or with spirits, varnishes, gums of any kind, waxes, or resins: but the first I conceive to be the best.

To print, take a glue bat, full size, for the subject, charge the copper-plate with the oil or colour, and take the impression with the bat from the plate, which impression transfer on the glass; if the impression be not strong enough, shake some dry colour on it, which will adhere to the most colour; or take any engraving or etching, or stamp, or cast, and, having charged it with the oil or colour, transfer it on the glass by means of prepared paper, vellum, leather, or any other substance that will answer: but I think the first the best. Any of the aforesaid engravings, etchings, stamps, casts, or device, may be charged with waters, oils, varnishes, or glutinous matters of any kind, reduced to a proper state, as is necessary in printing in general; any or all of these may be used alone, or mixed with the colours. When used alone, the colour is to be applied in powder as before mentioned.

To dip, mix the colour to about the consistency of a cream with any of the ingredients used for printing, wherein dip the glass vessel, keep it in motion till smooth.

To ground, first charge the glass vessel with oil of turpentine, with a camel-hair pencil, and while moist apply the colour in a dry powder, which will adhere to the oil, or,

or, instead of oil of turpentine, use any of the materials used for printing.

To float, mix the colour with any of the ingredients used for printing, to a consistency according to the strength of ground required, float it through a tube, or any other vessel, moving or shaking the piece of glass till the colour is spread over the part required.

OF ARTIFICIAL PEARLS.

It will not be improper to treat in this place of artificial pearls, as it is a branch of jewellery.

The ancients who wrote on the several sorts of precious stones, ranged pearls among the jewels of the first class; they have at all times been in high esteem, and have been employed particularly in adorning the fair sex.

The oriental pearls are the finest, on account of their size, colour, and beauty, being of a silver white; whereas, the occidental or western pearls seldom exceed the colour of milk. The best pearls are brought from the Persian Gulf, above the isles of Ormus and Bassora. They are found in Europe, both in salt and fresh waters; Scotland, Silesia, Bohemia, and Frisia, produce very fine ones; though those of the latter country are very small.

Pearls are concretions formed in several species of shells, as in the oyster and muscle. It is not perfectly ascertained in what way pearls are formed: by some they are supposed to be morbid concretions: by others it is supposed that they have their origin in a wound of the shell containing the animal. They consist of concentric layers of thin membrane, and carbonate of lime: and their brilliancy and iridescence are the result of the lamellated structure.

Art, which is always busy to mimic nature, has not been idle to bring counterfeit pearls to the greatest perfection: they are imitated so nearly, that the naked eye cannot

 distinguish

distinguish them from pearls of the first class, or the real ones.

We shall here present the curious with several receipts how to imitate pearls in the best manner, and after a method both easy and satisfactory, so as to render his labour pleasant, and make it answer his expectations.

To imitate fine Oriental Pearls.

Take of distilled vinegar two pounds, Venice turpentine one pound; mix them together into a mass, and put them into a cucurbit; fit a head and receiver to it, and, after you have luted the joints, set it, when dry, on a sand furnace, to distil the vinegar from it; do not give it too much heat, lest the stuff should swell up.

After this, put the vinegar into another glass cucurbit, in which there is a quantity of seed pearl, wrapt in a piece of thin silk, but so as not to touch the vinegar; put a cover or head upon the cucurbit; lute it well, and put it in *Bal. Mariæ* *, where you may let it remain a fortnight. The heat of the *Balneum* will raise the fumes of the vinegar, and they will soften the pearls in the silk, and bring them to the consistence of a paste; which being done take them out, and mould them to what bigness, shape and form you please. Your mould should be of fine silver, the inside gilt; you must refrain from touching the paste with your fingers, but use silver gilt utensils, with which fill your moulds; when you have moulded them, bore them through with a hog's bristle, or gold wire, and let them a dry a little; then thread them again on a gold wire, and put them in a glass; close it up, and set them in the sun to dry; after they are thoroughly dry, put them

* Balneum Mariæ, sometimes called Balneum Maris, is a bath of sand, heated by a fire, in which chemical apparatus are plunged, to submit their contents to a digestive heat.

into

into a glass matrass in a stream of running water, and leave them there twenty days; by that time they will contract the natural hardness and solidity of pearls. Then take them out of the matrass, and hang them in *mercury-water* *, where they will moisten, swell, and assume their oriental beauty; after which shift them into a matrass, hermetically closed up, to prevent any water coming to them, and let it down into a well, to continue there about eight days; then draw the matrass up, and on opening it you will find pearls exactly resembling oriental ones. This method is very excellent, and well worth the trouble.

Another Way to make Artificial Pearls.

TAKE oriental seed-pearls; reduce them into a fine powder, on a marble; then dissolve them in mercury-water, or clarified juice of lemons. To make more dispatch, set them in a cucurbit, in bal. mar. and you will see presently a cream arise at the top, which take off immediately: take the solution off the fire, and, when settled, pour off the liquid into another glass, and save it. You will have the pearl paste

* *Mercury-water*, so called by the workmen, is thus prepared. Take plate-tin of Cornwall; calcine it, and let the calx be pure and fine; then with one ounce of the calx, and two ounces of pure mercury, make an amalgam; wash it with fair water, till the water remains insipid and clear; then dry the amalgam thoroughly; put it into a matrass, on a sand bath, giving it such a heat as is requisite for sublimation. When the matter is well sublimated, take off the matrass, and let it cool. Take out that sublimate; add one ounce of Venice sublimate to it, and grind it together on a marble; put this into another matrass; close it well, and set it upside down in a pail of water; and the whole mass will dissolve in a little time: this done, filter it into a glass receiver; set it on a gentle sand heat to coagulate, and it will turn into a crystalline substance: this beat in a glass mortar, with a glass pestle, to a fine powder; sift it through a fine sieve, and put it into a matrass; stop it close up, and place it in *baln. mariæ;* there let it remain till it resolves again into water; which is *the mercury-water,* fit for the above-mentioned use.

at the bottom, with which fill your silver-gilt moulds; then put them by for twenty-four hours: bore them through with a bristle; close up the moulds, in barley dough, and put it in a oven to bake, and when about half baked, draw it out, take out your pearls, and steep them in the liquor you saved before, putting them in and taking them out several times: then close them up in their moulds, and bake them again with the like dough; but let it remain in the oven till it is almost burnt, before you draw it out. After you have taken your pearls out of their moulds, string them on one or more gold or silver threads, and steep them in mercury-water for about a fortnight; after which time, take and dry them in the sun, in a well-closed glass, and you will have very fine and bright pearls.

To make of small Pearls a fine Necklace of large ones.

TAKE small oriental pearls, as many as you will; put them into mercurial water fifteen days and nights together, and they will turn soft, like a paste; then have a pearl mould, made of silver; into this convey the paste by a silver spatula, or such like implement; but you must not touch the paste with your fingers, and be very careful to have every thing nice and clean about this work: when it is in the mould, let it dry; bore a hole with a silver wire through it, and let it stick there till you have more, but take care they do not touch one another; then have a glass wherein you may fix, as upon a pair of stands, your wires with the pearls: put them, well closed up, in the sun to harden, and when you find them hard enough, put them into a matrass; lute the neck very close, and sink it in a running spring of water for twenty days, in which time they will contract their natural colour.

It is asserted, by those who have wearied themselves with the hopes of forming small imperfect pearls into larger ones, that

that artificial pearls cannot be made of the materials of original pearls. The foregoing receipts are laborious and expensive; and that the reader may have some reward for his exertions, should the experiments balk his expectations, we shall add a tried and approved method of imitating pearls from other materials, which, when well executed, can only be distinguished from the real by their absolutely containing *fewer blemishes.* The method was kept a profound secret for many years.

Best Method of imitating Pearls.

TAKE the *blay* or *bleak-fish,* which is very common in the rivers near London, and scrape off, in a delicate way, the fine silvery scales from the belly. Wash and rub these in fair water, changing the water, and permitting the several liquors to settle: the water being carefully poured off, the pearly matter will be found at the bottom, of an oily consistence, called by the French *essence d'orient.* A little of this essence is dropped into a little hollow glass bead of a bluish tinge, and shaken about, so as to fill up all the cavities and surface of the internal part. When the essence is thoroughly dry, melted white wax is dropped into the beads, to give them weight, solidity, and security.

To blanch and cleanse Pearls.

FIRST soak and cleanse them in bran-water; then in milk-warm water, and last of all, steep them in mercury-water: then string and hang them in a glass; close it well, and set them in the sun to dry.

The bran-water is made thus: boil two large handfuls of wheaten bran in a quart of water, till all the strength of the bran is drawn out: use it thus; take a new glazed

earthen

earthen pan, in which put your pearls on a string, and pour the third part of the bran-water upon it; when they have soaked, and the water is just warm, rub your pearls gently with your hands, to clean them the better; continue this until the water is cold; then throw off that, and pour on another third part of the bran-water that is boiling; proceed with this as you did before, and when cold throw it away, and pour on the remainder of the water, still proceeding as before; after this, heat fair water, and pour it on your pearls, to refresh them, and to wash away the remains of the bran, by shifting them, and pouring on fresh warm water: this do thrice, without handling your pearls; then lay them on a sheet of clean white paper; and dry them in the shade; then dip them into mercury-water, to bring them to perfection.

Other Methods used in blanching Pearls.

POUND plaster of Paris to an impalpable powder; rub the pearls therewith very gently; this will not only cleanse them, but if you let them remain in this powder twenty-four hours afterwards, they will still be the better for it. White coral has the same effect, used in the like manner.

White tartar calcined and divested of all its moisture, is very good for the same purpose.

Salt, well dried and ground, is as effectual as any of the former things, for cleansing of pearls, by rubbing them therewith; and if afterwards you lay them up in some ground millet, it will contribute to their natural brightness.

OF

OF DOUBLETS.

A Doublet, among lapidaries, implies a counterfeit stone composed of *two* pieces of crystal, with proper colours between them; so that they may make the same appearance to the eye as if the whole substance of the crystal had been tinged with these colours.

The impracticability of imparting tinges to the body of genuine natural crystals, without depriving them of their brilliancy, gave inducements to the introduction of colouring the surface of them, so as to give them, when finished, the appearance of a gem. They have not the property which artificial stones have of being set transparent, as is required for drops of ear-rings, &c. but they suit very well for rings, and other ornaments which allow of an opaque back ground. They are made after the following manner:

A crystal, or glass in imitation of crystal, is to be cut by a lapidary into the shape of the precious stone it is to resemble; a brilliant, for instance, must be composed of two separate stones, or two parts of one stone, forming the upper and under parts of the brilliant, dividing the whole stone in a horizontal plane, a little lower than the middle. No division appearing between the two pieces when duly polished and placed on one another, the colour of the intended stone is put between them, after the following method:

Take of Venice or Cyprus turpentine two scruples, and add to it one scruple of the grains of mastich, chosen perfectly pure, free from foulness, and previously powdered. Melt them together in a small silver or brass spoon ladle, and put to them some one of the colouring substances mentioned hereafter, they being also finely powdered: stir them together as the colour is put in, that they may be thoroughly commixed. Warm then the doublets to the same degree of heat as the melted mixture, and paint the upper surface of the

the lower part, putting the upper one instantly upon it; and press them to each other, taking care that they are conjoined in the most perfectly even manner. When the paint or cement is quite cold and set, scrape off the redundant part of it which has been pressed out of the joint, so as to leave no colour on the outside of the doublet. They should be so set as skilfully to carry the mounting just above the joint, which will hide the artifice and secure the pieces from separating.

As the proportions vary in the receipt given in the former editions of this work, we shall here insert it, lest it be thought, on trial, to have the preference: it is as follows.

Method of making Doublets.

TAKE two drachms of clear mastich, and of the clearest Venetian or Cyprian turpentine sixteen drams; dissolve these together in a silver or brass spoon: if you find there is too much turpentine, then add a little more mastich to it, to bring it to a right temper. Then take what colour you please, as lake, dragon's blood, distilled verdigrise, or what colour else you design, for representing a particular stone; grind each by itself, in the nicest manner you possibly can, and mix each apart with the mixture of mastich and turpentine, which you ought to have ready by you; and you will find the lake to imitate the colour of a ruby, the dragon's blood that of a hyacinth, and the verdigrise the colour of an emerald. But in case you would have your colours, as it were, distilled, then get a little box, made of lime-tree, in the shape of an egg or acorn. This box must be turned at the bottom as thin as possible, so that the light may be seen through it. Then make a quantity of any one of the abovesaid colours, mixed with the mixture of mastich and turpentine, and put it into the little box, hung over a gentle glowing coal fire, or in summer-time

in

in the heat of the sun, where the colour will distil through very fine; scrape and put this into little boxes of ivory, to preserve it from dust, for your use; it is necessary to have to every different colour such a different wooden box.

When the colours are ready, take your crystals (first ground exactly to fit upon one another) and make your colours and stone of an equal warmth; lay your colour with a fine hair pencil on the sides of the crystals that are to be joined together; then clap them against each other as nimbly as possible: press them with your fingers close together; let them cool, and it is done.

The colour of the *Ruby* is thought by some ingenious artists to be best imitated by a fourth part of carmine, with some of the finest crimson lake that can be procured.

The *Sapphire* may be counterfeited by very high Prussian blue, mixed with a little of the above-mentioned crimson lake, to give it a tinge of the purple hue. Let not the Prussian blue be too deep coloured, or you must use the less of it, otherwise it will give a black shade which will obscure the brilliancy of the doublet.

The *Emerald* may be well imitated by distilled verdigrise, with a small portion of powdered aloes. But the mixture should not be strongly heated, nor kept over the fire after the verdigrise is added, for the colour is impaired by it.

The resemblance of the *Garnet* may be made by dragon's blood; which, if it cannot be procured of sufficient brightness, may be helped by a small quantity of carmine.

The *Amethyst* is imitated by the mixture of some Prussian blue with crimson lake; but the proportions can only be regulated by experience, as the parcels of blue and lake vary so much in their hues, and are of such different strengths of colours.

The *Yellow Topaz* may be counterfeited by mixing powdered aloes with a little dragon's blood, or by good Spanish anotto;

anotto; but the colour must be sparingly used, or the colour will exceed that of the stone.

The *Chrysolite, Hyacinth, Vinegar Garnet, Eagle Marine,* and other such weak and diluted colours, may be formed and imitated in like manner, only with less proportions of the due colours; for which purpose, those who employ their ingenuity and leisure hours in this pursuit, should obtain an original stone of each of those specified, keeping his eye perpetually watchful whilst mixing the colours. When these precautions are taken, and the operation is well conducted, it is practicable to bring the doublets to so near a resemblance of the true stones, as to deceive the best judges (when they are well set, and the joint hid) unless inspected in one direction only. The direction alluded to is, to hold them betwixt the light and the eye, so that the light may pass through the upper part and corners of the stone; when it will be readily perceived whether there be any colour in the crystal; which cannot be learned by looking down upon the doublet.

The Crystal Glue of Milan.

This is nothing else but grains of mastich, squeezed out of a linen bag by degrees over a charcoal fire, and like clear turpentine. Its use is, to unite two pieces of crystal together, to form a doublet, precisely in the manner before described.

INSTRUCTIONS

INSTRUCTIONS CONCERNING FOILS, OR METALLIC LEAVES, WHICH ARE LAID UNDER PRECIOUS STONES.

It is customary to place thin foils, or leaves of metal under precious stones, to make them look transparent, and to give them an agreeable colour, either deep or pale: thus, if you want a stone to be of a pale colour, put a foil of that colour under it; again, if you would have it deep, lay a dark one under it: besides, as the transparency of gems discovers the bottom of the ring they are set in, artificers have found out these means to give the stone an additional beauty.

These foils are made either of copper, or gold, or gold and silver together: we shall first mention those made of copper only, which are generally known by the name of *Nuremberg* or *German* foils.

Procure the thinnest copper plates you can, the thinner they are the less trouble they will give you in reducing them to a finer substance: beat these plates gently upon a well polished anvil, with a polished hammer, as thin as possible; but before you go about this work, take two iron plates, about six inches long, and as wide, but no thicker than writing-paper; bend them so as to fit one on the other; between these neal the copper you design to hammer for the foils, to prevent ashes or other impurities getting to it; then, taking them out, shake the ashes from them, and hammer the copper until cool. Then take your foils to the anvil, and beat them until they become very thin, and whilst you beat one number, put in another between the irons to neal; this you may repeat eight times, until they are as thin as the work requires. You must have a pipkin with water at hand, in which put tartar and salt, of each an equal quantity; boil, and put the foils in, and stir them continually, until, by boiling, they become white: then take them from the fire; wash

wash them in clean water; dry them with a fine rag, and give them another hammering on the anvil, until they are fit for your purpose.

Care must be taken in the management of this work, not to give the foils too much heat, to prevent their melting; neither must they be too long boiled, for fear of attracting too much salt.

How to polish and colour Foils.

Take a plate of the best copper, one foot long, and about five or six inches wide, polished to the greatest perfection: bend this to a convex shape, lengthwise, and fix it to a bench, or table: then take some whiting, and having laid some on the roll, and wetted the copper all over, lay your foils upon, it and with a polish-stone and the whiting, polish your foils, until they are as bright as a looking-glass; then dry them between a fine rag, and lay them up secure from dust. I shall now shew how these foils are coloured; but shall first give a short description of the oven, or furnace, requisite for that purpose.

The furnace must be but small and round (see plate 4, and the explanation) about a foot high, and as wide; cover the same with a round iron plate, in which is a round hole, about four inches wide; upon this furnace put another without a bottom, of the same dimension as the former, and let the crevices of the sides round about be well closed and luted: this furnace must also have a hole at top. The lower furnace must have a little door at bottom, about five inches big. Before this fix a sort of funnel, like a smoke-funnel to an oven, and lute it close to the furnace; then light some charcoal on your hearth, and when they burn clear, and free from smoke, convey them through the funnel into the furnace, till they come up so high as to fill half the funnel. When

When every thing is ready, and you have a clear fire, then begin to colour your foils in the following manner:

Lay the foils upon a pair of iron tongs; hold them over the hole that is at top of the furnace, so that the fumes of the coals may reverberate over them, and move them about till they are of a brownish violet colour; and this is done without any other vapour or smoke. When you have done with this colour, put it by; and if you would colour others of a sky blue, then put the foils upon the tongs as before; and whilst you, with one hand, are holding the foils over the holes, fling, with the other, some down-feathers of a goose, upon the live coals in the funnel, and with a red-hot poker press them down, to drive the smoke of the feathers up through the holes of the oven, which, by settling upon the foils, gives them a fine sky colour:- but you must have your eyes very quick upon them, and, as soon as you see that they have attracted the colour you design, take them away from the oven, to prevent their changing to some other colour: if you would have your foils of a sapphire blue, then first silver them over; which is done in this manner:

Take a little silver and dissolve it in aqua-fortis; when dissolved, put spring water to it; fling thin bits of copper into it, and the water will look troubled, and the silver precipitate and hang to the copper; pour off that, sweeten the silver with fair water, and let it dry in the sun; when dry, grind it on a porphyry: then take one ounce of tartar, and as much of common salt; mix and grind them all together, till they are well mixed; fling this powder upon the thin foils, and rub them with your finger backwards and forwards, and it will silver them; then lay them upon the polisher, pour water over them, and some of the powder, and rub it with your thumb till they are as white as you would have them: polish them with a polisher of blood-stone; and then holding them over the goose-feather smoke, they will take a fine dark blue.

To

To colour Foils of a Green Colour, for an Emerald.

You must first colour your foils of a sky blue, as directed before; then hold them over the smoke-hole, and below, in the funnel, lay, upon the red-hot iron plate, leaves of box, from which ascends a smoke that gives the foils a green colour; but before they contract that colour they undergo several changes, as blue, red, and yellow, &c. wherefore you must hold them till you have the green colour to your mind.

To colour the Foils of a Ruby Colour.

Put the shearings of scarlet cloth upon the coals, and holding the foils over the smoke-hole, they will contract a fine red colour.

The Colour of an Amethyst

This may be obtained by proceeding with your foils as for the blue or sapphire colour; for, before that blue colour comes, it first changes to an amethyst; as soon as you perceive this, take them off, and polish them.

How Foils are to be mixed with Copper and other Metals.

Take small-coal dust; put it into a little iron oven, and in the midst thereof a live charcoal; blow it till all the small-coal dust is lighted, and let this glow for two hours: when it is nearly all glown out, add such another quantity to it, and let it glow for an hour. At the top of your oven must

must be a round or square hole, with a close cover to it, in which hang the foils to some copper or iron wire: when your small-coal has glowed for about an hour, take a little iron bowl, and warm it well; put in it a little quantity of hair, and then set it upon the small-coal dust; shut the oven door, and open the top: this will draw the smoke through, and give the foils, first, the colour of a ruby, then of an amethyst, and, lastly, a sapphire. You may take out such colours as will serve your purpose; and if you want a green, let those foils hang, and burn sage leaves till the foils turn to a green colour. Take care to put but a few sage leaves in at a time.

For the ruby and hyacinth-colours use pure copper; but for an emerald and sapphire, take one part of gold, two parts of silver, and eight parts of copper; melt, and work them together.

THE ART OF IMITATING PRECIOUS STONES, OR OF MAKING ARTIFICIAL GEMS.

If metallic oxydes be melted with glass they tinge it of various colours: thus common glass acquires its tinge chiefly from the particles of iron interspersed in the sand and ashes made use of. To this belong the art of making glass pastes; or, as they are denominated, artificial gems. Their chief substance is a pure hard crystal-glass, coloured with metallic oxydes. The addition of calx of lead renders the glass more fusible. When oxyde of tin is added it becomes more or less opake. To these glass pastes the enamel belongs, which has been already described, and also the pigments used in porcelain painting.

The

The art of making artificial gems is arrived at such perfection, as to be capable of imitating precious stones in their lustre, colour, and beauty, equal to the natural ones, except in hardness, to obtain which has been, and still is, the endeavour of ingenious men. This art chiefly consists in rightly imitating the tints of those that are real: these must be prepared from such things as resist the fire, and do not change their colour.

You must therefore take such colours as change not, when mixt together: therefore, since blue and yellow make a green, you must take such blue as shall not injure the yellow when you mix them; and also such a yellow as shall not be detrimental to the blue; and so of the other colours. We shall give plain instructions to carry the ingenious artist with ease through his experiments, and having already given the method of preparing crystal glass, we shall now shew

The Way of preparing Natural Crystal.

TAKE natural crystal, the clearest you can get, no matter how big the pieces are; fill a large crucible with them, and cover it with a lid broader than the mouth of the crucible, to prevent the falling of ashes or coals into it: then put it into a small furnace, on burning coke: and when the crystal is thoroughly hot, cast it into a pretty large vessel of cold water. Then take it out of the water, dry it on an earthen plate, and put it into the same crucible again, cover it, and proceed as before, repeating it twelve times running, and changing each time the water: when the crystal easily breaks and crumbles, and is thoroughly white, it is a sign that it is calcined enough: if there appear any black parts in the veins, break off the white, and put these again into the furnace, and proceed therewith as before, till only the white remain behind.

After

After you have dried this calcined crystal thoroughly, grind it to an impalpable powder, on a marble or porphyry, and sift it through a lawn sieve. Of this powder of crystal, as it is used for all artificial gems of which we shall treat, it will be proper to have a sufficient quantity by you, to have recourse to when at work; and if you would succeed in this art, you must not use ordinary frit of crystal, be it ever so good; for that will not answer, or come up to the lustre or beauty of natural crystal.

To counterfeit an Opal.

At Harlem they make counterfeit opal glass, which is very lively, and whose several colours are supposed to be produced by different degrees of heat. When the composition is thoroughly melted, some of it, taken out on the point of an iron rod, being cooled, either in the air or water, is colourless and pellucid, but being put again into the mouth of the furnace upon the same rod, and turned round for a little time, acquires such various positions, as that the light falling on them being variously modified, represents the several colours observable in the true opal. And it is remarkable that these colours may be destroyed, and restored again by different degrees of heat.

To make a fair Emerald.

Take of natural crystal four ounces, of red-lead four ounces, verdigrise forty-eight grains, crocus martis, prepared with vinegar, eight grains; let the whole be finely pulverized and sifted: put this together in a crucible, leaving one inch empty; lute it well, and put it into a potter's furnace, where they bake their earthen ware, and let it stand there as long as they do their pots. When cold,

break the crucible, and you will find a matter of a fine emerald colour, which, after it is cut and set in gold, will equal in beauty an oriental emerald. If you find that your matter is not refined or purified enough, put it again, the second time, in the same furnace, and in lifting off the cover you will see the matter shining; you may then break the crucible, but not before; for if you should put the matter into another crucible, the paste would be cloudy and full of blisters. If you cannot come to a potter's furnace, you may build one yourself at a small expence *, in which you may put twenty crucibles at once, each with a different colour, and one baking will produce a great variety of artificial gems. Heat your furnace with hard and dry wood, and keep your matter in fusion twenty-four hours, which time it will require to be thoroughly purified; and if you let it stand four or six hours longer, it will not be the worse for it.

A deeper Emerald.

TAKE one ounce of natural crystal, six ounces and a half of red lead, seventy-five grains of verdigrise, ten grains of crocus martis, made with vinegar: proceed as directed before. *Or,*

Take prepared crystal two ounces, red-lead seven ounces, verdigrise eighteen grains, crocus martis ten grains, and proceed as before directed.

To make a Paste for imitating an Oriental Topaz.

THE colour of this stone is like water tinged with saffron or rhubarb: to imitate it, take of prepared natural crystal

* The reverberating furnace, which belongs to common portable furnaces, will do for one crucible at a time. *Ed.*

one

one ounce, of red lead seven ounces, finely powdered and sifted; mix the whole well together, and put it into a crucible, not quite full by an inch, lest the matter should run over, or stick to the cover of the crucible in rising; then proceed as directed above. *Or,*

Take prepared crystal two ounces, native cinnabar two ounces; *æs ustum* two ounces (all finely pulverized and sifted), four times as much calcined tin; put it all together into a crucible well covered, and proceed as before.

To make an Artificial Chrysolite.

THIS stone is of a green colour, and some have the cast of gold; to imitate it, take natural crystal prepared two ounces, red lead eight ounces, crocus martis twelve grains; mix the whole finely together, and proceed as before, only leaving it a little longer than ordinary in the furnace.

To counterfeit a Beryl, or Aqua Marina.

THIS stone is of a bluish sea-green: to imitate it, take two ounces of natural crystal prepared, five ounces of red lead, twenty-one grains of zaffre prepared (the whole finely pulverized); put them in a crucible, and cover and lute it; then proceed as directed above, and you will have a beautiful colour.

A Sapphire Colour.

A SAPPHIRE is generally of a very clear sky-colour, and is highly esteemed for its beauty. There are some of a whitish colour, like diamonds; others, of a full blue; and some, of a violet.

To make this paste, take of prepared rock crystal two ounces, red lead four ounces and a half, smalt twenty-six grains; pulverize and proceed as directed. This colour will come near to a violet.

Another, more beautiful, and nearer the Oriental.

Take two ounces of natural crystal prepared, six ounces of red lead, two scruples of prepared zaffre, and six grains of prepared manganese (all reduced to a fine powder); mix, and proceed as before.

Another, deeper coloured Sapphire.

Of prepared natural crystal take two ounces, red lead five ounces, prepared zaffre 42 grains, prepared manganese eight grains; the whole reduced to an impalpable powder, and mixed together; proceed as you have been directed, and you will have a colour deeper than the former, tending to a violet.

To make a Paste for an Oriental Garnet.

A garnet is much like a carbuncle; both, if exposed to the sun, exhibit a colour like burning coals, between red and yellow; and this is the true colour of fire. To imitate this stone, take two ounces of natural crystal prepared, and six ounces of red lead, also 16 grains of prepared manganese, and two grains of prepared zaffre, pulverize and mix the whole; put it into a crucible, and proceed as directed.

Another,

Another, deeper Garnet.

Of natural crystal prepared take two ounces, red lead five ounces and a half, prepared manganese 15 grains; pulverize all, and proceed as before directed.

ANOTHER PROCESS FOR COUNTERFEITING PRECIOUS STONES.

Take of black flint stones what quantity you please; put them into a pail of hot water, and, being wet, put them into a hot furnace (this will prevent their flying into small pieces;) or else warm them thoroughly by degrees, before you put them into the furnace. When you see that they are thoroughly red hot, quench them in fair water, and they will look of a fine white colour; dry and pulverize them very fine: this you may do in an iron mortar, but, as the powder may contract some of the iron, it will be proper, after you have taken it out, to pour on it some muriatic acid, which will clear it of the iron, and disengage it from impurities: wash it in several clean hot waters, afterwards.

Powder, thus prepared, is fit to be used for making the finest glass, and for imitating the clearest and most transparent gems, especially those that require the lustre of a diamond or ruby: as for a sapphire, emerald, topaz, chrysolite, amethyst, &c. your labour with the acid may be saved, if your mortar be bright and free from rust. Such as have a mortar of porphyry, or such like stone, have no occasion to use an iron one, but will save themselves a great deal of trouble.

If

If you cannot get black flint stones, you may content yourself with pebble; but flint is far preferable, and makes the glass of a harder substance than that made of pebble.

An approved Composition.

Of the above flint powder take three parts, refined nitre two parts, borax and arsenic one part. *Or,*

Of the flint powder three parts, nitre two, and borax four parts. *Or,*

Of the flint powder two parts, of refined pot-ash, or salt of tartar and borax, of each one part. *Or,*

Take of flint powder seven parts and a half, purified pot-ash five parts. *Or,*

Flint powder six parts and a half; nitre two and a half; borax one half; arsenic one half; and tartar one part.

To melt these Compositions; and how to tinge and finish your Work.

Take any one of the above specified compositions, and weigh what quantity you please, (one or two ounces); then mix it with the colour you design to have it of; for instance,

To make a Sapphire.

Take, to one ounce of the composition, four grains of zaffre; mix well together, and melt in a crucible; if you find the colour to your liking, proceed to finish it. You may make a sapphire either deeper or paler, according to what quantity you take of each ingredient; and it is the same with respect to other colours. A new practitioner in this

this art may make experiments in small crucibles, in order to acquaint himself with the nature of it.

I have already given receipts of most colours for imitating precious stones; but, nevertheless, I shall here lay down some experimental rules necessary to be observed.

Know then that crocus martis may be prepared different ways, and each will have a particular effect in colouring of crystals; one is prepared with vinegar, another with sulphur, a third with aqua-fortis, and a fourth by only a reverberatory fire.

To prepare Crocus Martis with Vinegar.

TAKE iron, or, which is better, steel filings; moisten and mix them up with good strong vinegar, in an earthen dish, or pan; after which, spread them, and let them dry in the sun; when dry, beat them fine in a mortar; moisten this powder with fresh vinegar, and dry and beat it again, as before; repeat this eight times running; afterwards, dry and sift it through a fine hair sieve, and it will be of the colour of brick-dust; but when mixt with glass, of a fine crimson colour. Put this powder up carefully, to preserve it from dust.

To prepare Crocus Martis with Sulphur.

TAKE iron, or steel filings, one part; sulphur three parts; mix them together, and put them into a crucible; cover and lute it well; then set it into a wind-furnace, and give it a strong fire, with charcoal, for four hours together; then shake it out, and, when cold, pulverize and sift it through a fine sieve: this powder put into a crucible; lute it, and place the same in the eye, or hole, of a glass furnace; let it stand there for fourteen days or more, and it

it will turn to a red powder, inclining to purple: this is a very useful ingredient for tinging of glass.

To prepare Crocus Martis with Aqua-Fortis.

MOISTEN some iron, or steel filings, in a glazed earthen plate, or dish, with aqua-fortis; set it to dry in the sun, or air; when dry, grind it to a fine powder; moisten it again with fresh aqua-fortis; dry it, and proceed as before, repeating it several times, till you see it of a high red colour: then grind and sift it through a fine hair sieve, and lay it up safe from dust.

To prepare Crocus Martis by a reverberatory Fire.

TAKE clean iron, or steel filings, and put it into a large pot, or pan, about the quantity of an inch high; cover it well, and put it into a reverberatory furnace, or any other place where it may be surrounded with a strong heat and flame; the iron will swell and rise in a fine red powder, so as to fill the pot, and even force up the lid; take off this powder, and you will find a good quantity of iron, caked together at the bottom, which put again into the furnace, where it will swell and rise into a powder as before; this continue until you have a sufficient quantity. This is the most valuable crocus, and of great use in the art of colouring or tinging of glass for counterfeiting of precious stones.

To make a fine Hyacinth.

TAKE of crocus martis, or of that iron powder prepared by reverberation, eight or ten grains to one ounce of the composition.

The

The Opal.

THIS is made of silver dissolved in aqua-fortis, precipitated by common salt; add to it some lead-stone, and mix it up with the above composition: it gives divers colours, so as to represent a natural opal.

Of Chrystal.

SUCH as will save themselves the trouble of preparing the composition for counterfeiting precious stones, may use fine crystal or *Venice* glass, beat in a clean mortar to a fine powder; of this take eight ounces, borax two ounces, refined nitre one ounce; which mixture you may melt and colour, with little trouble.

How to make a Diamond out of a Sapphire, according to PORTA'S *Description.*

WE used to make it, (the diamond) the surest way, in this manner: we filled an earthen pipkin, or crucible, with quick-lime, and laid the sapphire in the midst thereof, covering it first with a tile, and then with coals all over, blowing them gently until we had a clear fire; for if it is blown too much, it may occasion the breaking of the stone.

When we thought that the sapphire had changed its colour, we let the fire go out of itself, and took it out to see whether it was turned white; if so, then we laid it again in the crucible, in order to let it cool with the fire; but if it had not the right colour, then we augmented the heat again as before, and looked often to see whether the force of the fire had taken away all the colour, which was done in about five

five or six hours; if then the blue colour was not quite gone, we began our operation afresh, until it was white and clear. It is to be observed, that the heat of the fire, in the beginning of the operation, must increase by slow degrees, and also in the same manner decrease; for if the stone comes either too suddenly into the heat, or from the heat into the cold, it is apt to turn dark, or fly to pieces.

In like manner all other precious stones lose their colour, some sooner than others, according as they are either harder or softer. The amethyst is very light, and requires but a slow fire, for if it has too much heat, it becomes dark, or turns to a chalky appearance.

This is the art whereby inferior precious stones are changed into diamonds; they are afterwards cut in the middle, and a colour given them; and hence become a second sort of false diamonds, or doublets.

To make a fine Amethyst.

TAKE calcined flint-stone, and sift it through cambric, whereof take three quarters of an ounce; of purified potash, one quarter of an ounce; of borax, three quarters of an ounce; manganese, one quarter of an ounce: then add purified potash and borax, well mixed, to it; put it in a crucible into a wind furnace; give it at first a gentle heat until it is red hot, and thus keep it for a quarter of an hour; then give it a strong fire for two or three hours; at last pour it into a mould, and let it cool by degrees, to prevent its flying asunder.

To make a Ruby, or a fine Hyacinth.

TAKE acid of vitriol one ounce, and mix with the same weight of water; in this dissolve filings, or very thin beaten steel;

steel; set the glass on warm sand; filtrate the solution before it is cold; then set it in a cellar, and it will shoot into crystals, which pulverize; put it under a muffle, and stir it until you see it of a crimson colour; then take it off the fire, put it in a phial, pour on it good distilled vinegar, and after it has stood four days in a gentle warmth, pour off that vinegar, and pour fresh to it, and let it stand four days more; this repeat until the vinegar is observed to make no extraction; then pour off the vinegar, and there will remain at the bottom of your phial a crimson-coloured powder; sweeten this well with warm water. This is the tincture-powder for the ruby or hyacinth.

Then take black flints; calcine them well, as has been already directed, in order to bring them to a white powder, and sift this through cambric; take thereof, and of borax, of each half an ounce, and of the aforesaid tincture-powder, eight or nine grains; and mix well together in a crucible, and give it, for half an hour, a gentle fire: augment it by degrees, until you see your mixture in the crucible as clear as crystal, and of a crimson colour; then pour into a mould of what shape you would have it.

Plain Directions for polishing these Counterfeits, and also natural Gems.

It is to be observed that all glass, or artificial stones, may be cut and polished after one method, namely, by strewing finely powdered emery upon a leaden plate with water, and, holding the stone firm, grinding it in what form or shape you please.

If you fling ground tripoli, mixed with water, upon a pewter plate, and add a little copper ashes amongst it, it will have the same effect.

Pulverized antimony strewed upon a smooth plate of lead, with tripoli and vinegar, polishes not only glass, crystal, garnets,

nets, agates, and amethysts, but all other natural stones, except the diamond. The diamond is only cut with the diamond powder itself. Any such diamonds as can be touched by emery, lead, copper, or other metals, are false; and this is a good test for knowing a real diamond.

All other precious and hard stones may be ground, or cut, with metal and emery; but the polishing is different.

The sapphire is, next to the diamond, the hardest; it may be polished best with antimony and vinegar, or lead, or with calcined flint-stone and water, upon copper.

The ruby is polished like the sapphire.

The emerald and turquoise are polished with potter's clay and water, on pear-tree wood; or with tripoli, upon wood; or with emery, upon pewter.

The beryl is polished with calcined mother-of-pearl, or calcined muscle-shells, upon a board covered with white leather.

A balass is polished with antimony upon copper.

The cornelian, onyx, agate, and jasper, upon tin; or with tripoli, or calcined flint, upon pear-tree wood; or with antimony upon lead.

The amethyst, topaz, turquoise, and other soft stones, are polished upon a board of lime-tree wood, upon a plate of tin, and upon a board with leather. First polish top and bottom, upon the wood: the small diamond cuts are done upon the plate of tin, and receive the last polishing upon the board that is covered with leather.

A Powder for polishing soft Stones.

TAKE iron scales, and mix them with vinegar and salt, and let them stand thus infused for three or four days, the longer the better; then grind the mixture very fine; dry it, and put it in an earthen pot well luted; give it a good fire, and it will be fit for use.

PART

PART IV.

THE

ART OF MAKING GLASS;

WITH

THE ART OF PAINTING, AND MAKING IMPRESSIONS UPON GLASS, AND OF LAYING THEREON GOLD OR SILVER; TOGETHER WITH THE METHOD OF PREPARING THE COLOURS FOR POTTER'S-WORK, OR DELFT-WARE.

GLASS is a transparent brittle body, and invariably contains two essential ingredients, viz. silica and an alkali. The former may be obtained of various degrees of purity, according to the nature of the glass required. The siliceous material used in this country is generally sea-sand, which consists of minute rounded grains of quartz, so small as to require only to be washed before it is used. The alkali is either potash or soda.

Silica, when mixed with the fixed alkalies, and exposed to a strong heat, enters readily into fusion. It melts also when heated with some of the alkaline earths, especially lime, provided a little alumina be present. These mixtures are very ductile while in fusion, and may be readily moulded into any shape.

shape. If they be suddenly cooled below the temperature at which they become solid, they retain their transparency, and assume those peculiar properties which belong to the substance called glass. Glass then is a combination of the fixed alkalies, or alkaline earths, with silica, either alone or conjoined with alumina, brought into complete fusion, and then suddenly congealed. Metallic oxydes are sometimes added: they assist the fusion like the alkalies, and communicate frequently peculiar colours to the vitreous mass. The method of making glass was known at a very early period. According to Pliny, the discovery was owing to an accident. Some merchants, with a ship-load of soda from Egypt, had cast anchor at the mouth of the river Belus, in Phœnicia, and were dressing their dinner on the sand. They made use of large lumps of soda to support their kettles, and lighted fires under them. The heat melted the soda and the siliceous sand together, and the result was glass. For some time after this accidental discovery the manufacture of glass was confined to the river Belus. This manufacture seems to have been carried to a considerable degree of perfection among the ancients. They mention drinking glasses, glass prisms, and coloured glasses of various kinds. It was usual for them to melt the materials of their glass into a black mass called ammonitrum, of which statues were sometimes made.

This ammonitrum was again melted and purified by refiners. Glass panes seem to have been first used in windows in the third century, but they did not come into common use till long after. While glass is in fusion, the substances which enter into its composition may be considered as combined with each other so as to form a homogeneous mass similar to water, holding a variety of salts in solution. If it be cooled down very slowly, the different tendency of the constituents to assume solid forms at peculiar temperatures, will cause them to separate successively in crystals; just as the salts held in solution in water assume the form of crystals,

crystals, as the liquid is slowly evaporated. But if the glass be quickly cooled down to the point of congelation, the constituents have not time to separate in succession, and the glass remains the same homogeneous compound as while in a state of fusion; just as would happen to a saline solution if suddenly exposed to a cold sufficient to congeal it completely. Hence it appears that the vitreous quality depends entirely upon the fusibility of the mixture, and the suddenness with which it is cooled down to the point of congelation. The substance, though solid, is precisely the same as to its chemical composition as if it were still in fusion; the sudden cooling having fixed the constituents before they had time to assume a new arrangement. All fusible mixtures of the earths proper with fixed alkalies, alkaline earths, or metallic oxydes, may be made at pleasure to assume the form of glass, or the appearance which characterizes stone or porcelain, according to the rate of cooling; and glass may be deprived of its vitreous form merely by fusing it, and cooling it down with sufficient slowness to enable the constituents to separate in succession. Many curious experiments on this subject were made by Reaumur and Lewis, who pointed out the method of converting different kinds of glass into an opaque, white, hard, refractory substance like porcelain, which is commonly distinguished by the name of Reaumur's porcelain. Dr. Lewis, by a variety of experiments, demonstrated that all kinds of glass could not be converted into porcelain. He succeeded only with those that were composed of a variety of constituents. The reason is obvious; such glasses alone contain ingredients that become solid in succession. Green glass succeeded best with him. Indeed this glass is very apt to acquire a crystallized form. The temperature best suited to the change is that in which the glass is softened without being melted. It was the curious experiments of Sir James Hall on basalt and greenstone, that first explained upon what the vitreous state of substances depends. He found that glass (consisting of various earthy bodies) always

loses

loses its vitreous state, and assumes that of a stone, if more than a minute or two elapses while it is cooling down from complete fusion to the point at which it congeals. There are different kinds of glass in common use in this country for various purposes. The finest are plate glass, of which looking-glasses are made, and flint-glass, or crystal, used for the finest vessels. These are perfectly transparent and colourless, heavy and brilliant. They are composed of fixed alkali, pure siliceous sand, calcined flints, and litharge. The manufacturers conceal the proportions of their ingredients with great care. The plate-glass is poured melted upon a table covered with a sheet of copper. The plate, as cast, is about an inch thick; but it is ground down to the proper degree of thinness, and then polished. Flint-glass contains much oxyde of lead. Dr. Lewis extracted from it one-fourth of its weight of that metal in a malleable state. Though it be very solid, it does not seem to be absolutely impervious to gaseous bodies, at least when heated nearly to the melting point. Dr. Lewis surrounded a piece of it with charcoal powder, and kept it for some time in a heat not sufficient to melt it. The lead was revived in drops through the whole substance of the glass. Dr. Priestley ascertained, that glass tubes filled with hydrogen gas, and heated, became black, from the revival of the lead. When alkaline hydrosulphurets are kept in glass phials, the inside is soon coated with a black rust, which is nothing else than lead separated by the sulphur from the glass. Crown-glass is made without lead: it is therefore much lighter than flint-glass. It consists of fixed alkali, fused with siliceous sand. As the earthy matters employed by the glass-makers are seldom quite pure from some mixture of iron or similar ingredient, the glass would have a green colour unless some means were taken to remedy it. The addition of black oxyde of manganese remedies this defect; hence it is used for that purpose by the glass-makers, and was formerly called soap of glass. If too much be used, the glass acquires a purple

purple cast; a colour very common in the window-glass made in England. In Scotland the window-glass has always a considerable shade of green. As no exact analysis has yet been made of the finer kinds of glass, we are not acquainted with the proportion of its constituents: they no doubt vary considerably. As the fixed alkalies are volatilized by a strong heat, it would be worth while to examine whether a portion of them is not driven off while the glass is in fusion, or whether the previous steps of the process prevent that from happening. Bottle-glass is the coarsest and cheapest kind; little or no fixed alkali enters into its composition. It consists of an alkaline earth, usually lime, combined with alumina and silica. In this country it is composed of sand and the refuse of the soap-boiler, which consists of the lime employed in rendering his alkali caustic, and of the earthy matters with which that alkali was contaminated.

A specimen of this, analysed by Vauquelin, was found to be composed of

Silica - - - - - -	57
Lime - - - - - -	31
Alumina - - - - - -	4
Oxydes of manganese and iron - -	4
Loss - - - - - -	4
	100

Besides a portion of potash so small that it could not be appreciated. Of the different species of glass, the most fusible is flint-glass, and the least fusible bottle-glass. According to the experiments of Saussure, flint-glass melts at the temperature of 19° Wedgewood, crown-glass at 30°, and bottle-glass at 47°. The specific gravity of glass differs considerably, according to its constituents.

The properties that distinguish good glass are well known. It is perfectly transparent; its hardness is very considerable; its specific gravity varies from 2·3 to 4, according to the proportion of metallic oxyde which it contains. When cold it

is brittle: but at a red heat it is one of the most ductile bodies known, and may be drawn out into threads so fine as to be scarcely visible to the naked eye. It is almost perfectly elastic, and of course is one of the most sonorous of bodies. There are but few chemical agents which have any action on it. Fluoric acid dissolves it with great rapidity, and so do the fixed alkalies when assisted by heat. Dr. Priestley has shown also, that the long continued action of hot water is capable of decomposing it: a discovery which explains sufficiently the siliceous earth obtained by Boyle and Margraff, when they subjected water to tedious distillations in glass vessels. After mixing the materials of glass together, it is usual to expose them for some time to a moderate heat. This serves several purposes. It drives off all combustible bodies, which may happen to be mixed with the sand; it produces a commencement of combination which makes the glass afterwards less liable to corrode the clay pots in which it is melted; and the alkali, by this incipient combination, is not so apt to be volatilized; which might be the case if the materials were exposed at once to a violent heat. The mixture, after being thus heated, is called the frit. Through the domes in which the frit is heated, it is usual to see very thin bubbles of glass passing; a proof that some of the materials are volatilized during this first part of the process. The frit, while still hot, is introduced into large pots made of a mixture of pure clay and baked clay, and exposed to a heat sufficient to melt it completely. The fusion must be continued till the effervescence occasioned by the separation of the carbonic acid from the soda has subsided; and the opaque scum, known by the name of glass-gall, which collects on the surface of the glass, must be removed. This scum is occasioned by the common salt and other foreign bodies, which are always mixed with the soda of commerce. When the fusion has been continued the proper time, the furnace is allowed to cool a little. In that state the glass is exceedingly ductile, and readily assumes any shape that the workman

workman pleases. If the glass vessels, after being formed, were cooled rapidly, they would contract unequally, and become in consequence so brittle as to fall to pieces whenever they were handled. To prevent this inconvenience they are put into a large red hot furnace, which is allowed to cool very slowly to the temperature of the air. This process is called annealing. Glass is often tinged of various colours by mixing with it, while in fusion, some one or other of the metallic oxydes.

Blue glass is formed by means of oxyde of cobalt.
Green, by the oxyde of iron or of copper.
Violet, by oxyde of manganese.
Red, by a mixture of the oxydes of copper and iron.
Purple, by the purple of oxyde of gold.
White, by the oxyde of arsenic and of zinc.
Yellow, by the oxyde of silver, and by combustible bodies.

Glass is so extremely elastic, that if the force with which glass balls strike each other be reckoned 16, that with which they recede by virtue of their elasticity will be nearly 15. When it is suddenly cooled, it becomes highly brittle, which is oftentimes attended with surprising phenomena. Hollow balls made of annealed glass, with a small hole in them, will fly to pieces by the heat of the hand only, if the hole by which the internal and external air communicate be stopped with the finger. Lately, however, such balls have been found out to resist very smart strokes of a hammer, although they are easily shivered in pieces by the fall of very minute and light bodies falling into their cavities. These glasses may be made of any shape; all that is to be observed is, that their bottoms be made thicker than their sides. These experiments were made before the Royal Society, by whose members various reasons for the fact have been assigned. Glass appears more fit for the condensation of vapours than metallic substances are. An open glass filled with water, in the summer time, will gather drops of water on the outside, just as far

as the water in the inside reaches; and a person's breath blown on it, manifestly moistens it. Glass also becomes moist with dew, which metals do not. A drinking glass filled with water, and rubbed on the brim with a wet finger, yields musical notes, higher or lower, as the glass is more or less full; and will make the liquor frisk and leap. Glass is moreover possessed of great electrical virtues.

It has been stated that glass is made of sand, flints, &c. &c.; but there are various saline matters which ought to be particularly mentioned. *Polverine* or *rochetta* is procured from the Levant, and is prepared from a plant called *kali*, which is cut down in the summer, dried in the sun, and burnt in heaps, either on the open ground, or on iron grates; the ashes falling into a pit, grow into a hard mass, fit for use when it has been purified. *Kelp*, which grows on our sea coasts, and the ashes of the *fucus vesiculosus*, furnish a similar salt. Pearl-ash, and pot-ash, both of which are procured from vegetable matters, are purified, and employed in glass-making: so also is nitre and borax, and, occasionally, the purified *barilla* of Spain, called *soda*. Other fluxes are used, such as calcined lead, arsenic, smith's clinkers, &c. In general it may be observed, that the more metallic preparations enter the composition of glass, so much the more dense, ponderous, fusible, soft, and coloured it will be.

To prepare Ashes for making Glass.

Take what quantity, and what sort of wood-ashes you will, except those of oak; have a tub ready with a spigot and faucet towards the bottom, and in this tub put a layer of straw, and fling your ashes on it; then pour water upon them, and let the ashes soak thoroughly until the water stands above them: let it thus continue over night; then draw out the faucet and receive the lye in another tub, put under the first for this purpose: if the lye looks troubled, pour it again on

on the ashes, and let it settle until it runs clear and is of an amber colour. This clarified lye put by, and pour fresh water on the ashes; let this also stand over night; then draw it off, and you will have a weak lye, which, instead of water, pour upon fresh ashes: the remaining ashes are of use in the manuring of land.

After you have made a sufficient quantity of lye, pour it into an iron cauldron, bricked up like a brewing, or washing, copper; but let it not be filled above three parts full. On the top of the brick-work place a little barrel with lye; towards the bottom of which bore a hole, and put a small faucet in, to let the lye run gently into the cauldron, in a stream about the roundness of a straw; but this you must manage according to the quantity of lye, for you ought to mind how much the lye evaporates, and make the lye in the barrel run proportionally to supply that diminution. Care must be taken that the lye do not run over in the first boiling; but if you find it will, put some cold lye to it, and slacken the fire, and let all the lye boil gently to a dry salt: when this salt is cold break it, and put it into the calcar (see the next article), and raise your fire by degrees until the salt is red hot, yet so as not to melt it. If you think it calcined enough, take out a piece and let it cool; then break it in two, and if it is thoroughly white, it is done enough; but if there remains a blackness in the middle it must be put in the calcar again, until it comes out thoroughly white. If you will have it still finer, you must dissolve it again, filtrate it, boil it, and calcine it as before: the oftner this is repeated the more will the salt be cleared from the earthy particles; and it may be made as clear as crystal, and as white as snow. Of this may be made the finest glass possible.

According to M. Merret *, the best ashes in England are burnt

* Dr. Thomson, to whose admirable work on Chemistry we have been indebted for part of this article, says, the fullest account of glass-making is to be found in a treatise by Neri, an Italian. Dr. Merret, an Englishman, translated

burnt from thistles, and hop-stalks, after the hops are gathered: and among trees, the mulberry is reckoned to afford the best salt.

The most thorny and prickly plants are observed to yield better, and more salt than others; also all herbs that are bitter, as hops, wormwood, &c. Tobacco stalks, when burnt, produce likewise plenty of salt: and it is observed that fern ashes yield more salt than any other ashes.

Description of a Calcar.

In glass-making, the name of *calcar* is given to a small oven or reverberatory furnace in which the first calcination of sand and salt of pot-ash is made, for the purpose of turning them into *frit*. This furnace is fashioned much after the manner of an ordinary baker's oven, ten feet long, seven feet broad in the widest part, and two feet deep. On one side of it is a trench six inches square, the upper part of which is level with the calcar, and separated only from it at the mouth by bricks nine inches wide. Into this trench they put sea-coal, the flame of which is carried into every part of the furnace, and it is reverberated from the roof upon the frit, or other materials put within it, over the surface of which the smoke flies very black, and goes out at the mouth of the calcar: the coals are placed on iron bars, laid in the trench; and the ashes fall through.

ranslated it into Latin, and enriched it with notes. Kunkel translated this Latin edition into German, with additions, which were the result of his own numerous experiments on glass-making. Kunkel's work was translated into French in 1752. An elaborate account of glass-making has been published in the "Arts et Metiers;" and since that a small volume on glass-making has been written in French, by Loysell.

To

To make the Glass Frit.

TAKE white silver sand; wash it, and separate all the impurities from it, and let it dry, or, rather, calcine it. Of this take sixty pounds, and of prepared ashes thirty pounds; mix them well together; then set them in the melting furnace; the longer it is melting the clearer will the glass be made. If it stands for two days and two nights, it will be fit to work with, or to tinge with what colour you please. Before you work it, add forty pounds of lead and half a pound of manganese to it. *Or,*

Take ashes, prepared as above, sixty pounds; of prepared silver sand one hundred and sixty pounds, arsenic four pounds, white lead two pounds, clear dry nitre ten pounds, borax two pounds; mix all well together, and proceed as has been directed, and you will have a beautiful crystal. Other proportions are used.

Glass-blowing.

GLASS-BLOWING, the art of forming vessels of glass; the term, however, is exclusively applied to those vessels which are blown by the mouth. The operation is exceedingly simple, the workman has a tube of iron (see Plate V.), the end of which he dips into a pot of melted glass, and thus gathers a small quantity of glass on the end of it, he then applies the other end of the tube to his mouth and blows air through it, this air enters into the body of the fluid glass, and expands it out into a hollow globe, similar to the soap bladders blown from a tobacco-pipe. Various methods are used to bring these hollow globes into forms of the different utensils in common domestic use. The first and greatest of the glass-blowers' implements is the furnace (see Plate V.), which

which consists of two large domes set one over the other, the lower one stands over a long grating (on a level with the ground), on which the fuel is placed; beneath the grate is the ash pit, and a large arch leading to it conveys air to the furnace. In the sides of the lower dome, as many holes or mouths are made as there are workmen to make use of the furnace, and before each mouth a pot of melted glass is placed; the pots are very large, like crucibles, and will hold from three to four hundred weight of liquid glass, they are supported upon three small piers of brickwork, resting on the floor of the furnace. The form reverberates the flame from the roof down upon the pots, and they are placed at some distance within the furnace, that the flame may get between the wall and the pots. The upper dome is built upon the other, and its floor made flat by filling up round the roof of the lower dome with brick-work, there is a small chimney opens from the top of the lower dome into the middle of the floor of the upper one, which conveys the smoke away from it, and a flue from the upper dome leads it completely from the furnace. The upper dome is used for annealing the glass, and is exactly similar to a large oven; it has three mouths, and in different parts a small flight of steps leads up to each.

A green-glass furnace is square; and at each angle it has an arch for annealing or cooling glasses, or bottles. The metal is wrought on two opposite sides, and on the other two they have their colours, into which are made linnet holes for the fire to come from the furnace to bake the frit, and to discharge the smoke. Fires are made in the arches to anneal the work, so that the whole process is done in one furnace.

These furnaces must not be of brick, but of hard sandy stones. In France, they build the outside of brick; and the inner part, to bear the fire, is made of a sort of fuller's earth, or tobacco-pipe clay, of which they also make their melting-

melting-pots. In Britain the pots are usually made of Stourbridge clay.

It is observed, that the roughest work in this art is the changing the pots when they are worn out or cracked. In this case the great working hole must be uncovered; the faulty pot must be taken out with iron hooks and forks, and a new one must be speedily put in its place, through the flames (for glass-furnaces are always kept burning) by the hands only. In doing this, the man guards himself with a garment made of skins, in the shape of a pantaloon, that covers him all but his eyes, and is thoroughly wetted all over: his eyes are defended by proper shaped glass, of a green colour.

We now come to describe the smaller implements, which are as follows: (1). A bench, or stool, with two arms at its ends, which are a little inclined to the horizon. (2). A pair of shears, or rather plyers, formed of one piece of steel: they have no sharp edges, and spring open of themselves, if permitted. (3). A pair of compasses to measure the work, and ascertain when it is brought to the proper size. (4). A pair of common shears for cutting soft glass. (5). A blowing pipe, which is a wrought iron tube, three or four feet long, covered with twine at the end, by which it is held.

We may now explain the use of these tools in the manufacture of some vessel, as a lamp, &c.

The operation is conducted by three workmen. The first takes the blowing pipe, and after heating it to a red heat at the mouth of the furnace, dips it into the pot of melted glass, at the same time turning it round that it may take up the glass, which has then much the consistence of turpentine; in the quantity of metal he is guided by experience, and must proportion it to the size of the vessel to be blown, he then brings it from the furnace to the stool, and rolls the lump of glass upon it to bring it to a round form, after which he blows through the pipe, resting the glass upon an iron plate behind

behind the stool, and rolling it backwards and forwards. The blowing makes the glass hollow, and he has several methods of bringing it to a proper shape to be worked; by simply blowing, it would assume a figure nearly globular, if he wants it any bigger, in the equatorial diameter, he lays the pipe on a hook driven in the side of the stool, and turns it round very quickly, the centrifugal force soon enlarges it in the equator. If, on the othar hand, he wishes to lengthen its polar diameter, he holds the pipe perpendicular, the glass hanging downwards, its weight lengthening it, and to shorten the polar diameter he holds the pipe upright, the glass at the top; by blowing through the pipe the capacity is increased, and the thickness of the glass of the vessel diminished. We now suppose, that by a very dexterous application of the above methods, the workman has brought it to a proper shape, he now carries it to the mouth of the furnace, and holds it in to get a fresh heat, (for by this time it is become too stiff to work easily), taking care to turn it round slowly, that it may not alter its figure. The vessel in this stage is delivered to the second, or principal workman, the other two being only assistants, he is seated upon the stool, and lays the blowing pipe with the glass at its end across its arm, and with his left hand rolls the pipe along the arms, turning the glass and pipe round at the same time; in his right hand he holds the pliers, whose blades are rubbed over with a small piece of bees-wax, and as the glass turns round presses the blade of the shears against it, following it with the shears as it rolls, at the end or side as occasion requires, until he has brought it to the proper size, which he determines by the compasses, though not materially altering its figure, the first workman kneeling on the ground, and blowing with his mouth at the end of the pipe when directed by his principal. The third workman now produces a small rod, which is dipped into the melting-pot to take up a small piece of metal to serve as cement, the end of this rod he applies to the centre of the glass just opposite

posite the blowing pipe, the principal workman directing it, by holding its end between his pliers, the rod by the small piece of glass on its end immediately sticks to the glass vessel, and the third workman draws it away, both workmen turning their rods round, but in contrary directions; this operation forms a short tube on the end. The principal workman then takes the short tube between the blades of a pair of pliers, exactly like the others, but which are not covered with bees-wax, the cold of these pliers instantly cracks the glass all round, and a very slight jerk struck upon the rod breaks it off. A hole is now made in the end of the glass, which is enlarged by the pliers while the glass is turned, until the neck is brought to the proper size and length to fit the brass cap as before described, and the inferior half of the lamp is brought to its shape and size in the same manner. In order to form the upper half, the third workman has in the mean time been preparing a round lump of glass on the end of one of the rods, which he applies hot to the end of the neck, it being guided by the principal workman, and it immediately holds tight, he then breaks off the other neck by the cold pliers, and thus separates it from the blowing pipe. The glass is now heated a third time, and brought from the furnace to the principal workman, who enlarges the small orifice at the end by turning it round, and holding the pliers against it, until he enlarges it to the right shape; it is now finished, and the third workman takes it to a stool strewed over with small coals, he rests the rod upon the edge of the stool, and with a file files the joint at the bottom neck, and it soon breaks off, and the lamp falls upon the coals, the distance being so very small, as to be in no danger of breaking; a boy now puts the end of a long stick into the open mouth of the glass, and thus carries it to the annealing oven, where it remains some hours, when taken out it must be cooled gradually, and is fit for sale.

A smaller

A smaller Furnace, for Glass, and other Experiments.

YOUR furnace must be built according to the situation and dimension of your room, about a yard square: at the bottom leave a hole, A, fig. 1. plate VI. which is the receiver of the ashes, and also the drawer of the wind to the fire, which you may make as fierce as you will, by exposing it more or less to the open air. B, is an iron grate, about a quarter and a half above the hole A.

C, C, are holes over the grate, wherein you put the fuel; over the grate is a bricked vault, which the flames draw through the hole D, in the upper vault E.

F, F, are two or more holes, through which you put the crucibles in; you may make one on each side, and make cakes of such clay as the glass makers use, to set them before the holes, and by this means mitigate the flames, which might sometimes strike too fierce upon the upper vault, and give them a little vent.

G, is a hole in the upper vault, which may be covered and uncovered as much as you will, and the flame may either go strait through the funnel H, which at the top is provided with the cover I, and which, on such occasions, must be taken off; or else, in putting on the cover I, you may convey a reverberatory fire through the funnel K, into another little reverberatory furnace, which will be very useful for calcining and preparing several materials as may happen to be used.

The inside of this furnace must be lined smooth, with such potters clay as the glass-makers use, and two or three inches thick. And having finished it according to this direction, you may place a good many crucibles in at a time, making the holes through which you convey your larger crucibles higher, so that the rim of the crucible may come even with the bottom of the hole, and you may easily convey

PLATE V.

GLASS BLOWING.

vey a ladle, spatula, or any thing else through them. This furnace is the most compendious and useful that can be contrived for a novice in the art of glass-making. Fig. 2. plate 6, is the appearance of the outside.

Method of making Plate-Glass.

The materials of the finest plate-glass are white sand, soda, and lime, to which are added manganese and zaffre, or any other oxyde of cobalt for particular colouring purposes. The sand is of the finest and whitest kind, and is previously passed through a wire sieve of moderate closeness into water, where it is well stirred and washed till all dirt and impurity are got rid of. The sharpest grained sand is preferred, and indeed it is found that the grains of moderate size melt with the alkali sooner than either the very fine dust or the larger fragments. The alkali used is always soda, and there seems good reason to prefer this to potash, as glasses made with soda are found to be softer and to flow thinner when hot, and yet to be equally durable when cold. Besides, the neutral salts, with the basis of soda which constitute the glass-gall in this instance, such as the muriate and sulphate of soda, appear to be dissipated more readily by the fire than the corresponding salts of potash. Lime is of considerable use, and adds much to the fusibility of the other materials, supplying in this respect the use of litharge in the flint-glass. Too much lime however impairs the colour and solidity of the glass. The colouring, or rather discolouring, substances used, are azure, or cobalt blue, and manganese. The latter is here in the state in which its effect is that of giving a slight red tinge, which mixes with the blue of the cobalt, and the natural yellow of the other materials; and if properly proportioned they neutralize each other so that scarcely any tint remains. Besides these ingredients there is always a great quantity of fragments of glass arising from

what

what is spilt in the casting and the ends cut off in shaping the plates, which are made friable by quenching in water when hot, and used in this state with the fresh materials. Of the above materials the sand, soda, lime, and manganese are first mixed together with great care, and are fritted in small furnaces, built for this purpose, the heat being gradually raised to a full red-white, and kept at this point with frequent stirring till the materials undergo no further change, nor give any kind of vapour. The azure and the glass fragments being already perfectly vitrified, are not added till towards the end of the process, which lasts about six hours. The glass-house for this manufacture differs in several particulars from the common houses for blowing glass, being about 18 feet long and 15 wide, made of good bricks. They are particularly distinguished from the common furnaces by containing two kinds of crucibles, the larger ones called "pots" are in the form of an inverted and truncated cone, and in these the glass is melted. The others are smaller, called cuvettes. Another essential part of this furnace is the flat table (of which there is one corresponding with each pot) on which the glass is cast. These tables are of copper-plate, about ten feet by six, supported by masonry; and contiguous to each, on the same level, are flat ovens, heated from underneath, upon which the glass when cast and sufficiently cooled, may be slid without difficulty from off the table, and there annealed. The tops of the flat ovens and the tables are on a level with the corresponding opening of the furnace, whence the cuvettes are withdrawn. When the glass is thoroughly melted and fine, the cuvette is filled in the following way: the workman takes a copper ladle about ten inches in diameter, and fixed to an iron handle seven feet long, plunges it into the glass pot, brings it up full of the melted glass, and empties it into the cuvette, the ladle being supported at the bottom by a strong iron rest, held by two other workmen, lest the red-hot copper should bend and give way with the weight of the glass within. The cuvette being filled,

filled, is suffered to remain in the furnace for some hours, that the bubbles formed by this disturbance of the glass may have entirely disappeared, and the samples taken out from time to time become quite clear and limpid. The door of the furnace is now opened, the cuvette is slid out and pulled upon a low iron cradle, and immediately drawn on to the side of the copper table, where it is hoisted up by a tackle and iron chains, and overset upon the table, on which a thick flood of melted glass flows and spreads in every direction to an equal thickness. It is then made quite smooth and uniform at the surface, by passing over it a heavy hollow roller or cylinder of copper made true and smooth by turning, after it is cast, and weighing about 500 pounds. At the same time the empty cuvette is returned by the iron cradle to its proper place within the furnace. The number of workmen required for the whole process of casting is at least twenty, each of which has his separate employment. The plate being cast, the inspector examines whether there are any bubbles on any part of the surface, and if found, the plate is immediately cut up through them. The plate being now cool is slid by an iron instrument from the casting table to the contiguous annealing oven, previously well heated, and is carefully taken up and ranged within it. Each oven will contain six entire plates, and when full, all the openings are stopped with clay, and the plates allowed to remain there for ten days or a fortnight, to be thoroughly annealed. When fit to be taken out of the annealing oven they are sent away to receive all the subsequent operations of polishing, silvering, &c. but first the edges are cut smooth and squared. This is done by a diamond, which is passed along the surface of the glass upon a square ruler in the manner of glaziers, and made to cut into the substance of the glass to a certain depth. The cut is opened by gently knocking with a small hammer on the under side of the glass just beneath, and the piece comes off, and the roughnesses are removed

by

by pincers. The plate is then finished as far as the glass-house business is concerned.

The glass is now to be polished, which is done with sand and water; the glass being first fastened down to a wooden frame, with plaster of Paris, the operation is performed by means of another glass, fastened in a frame which is made to rub upon the other, wet sand being interspersed between the two. As the surfaces of the plates wear down, the sand is used finer and finer. Emery is next used of two or three degrees of fineness, which brings the glass to an even surface, but it is still perfectly opaque. To render it transparent, colcothar, which is the residue left in the retorts of the aqua-fortis makers, is applied. The polishing instrument is a block of wood, covered with several folds of cloth and carded wool, so as to make a firm elastic cushion. This block is worked by the hand; but to increase the pressure of the polisher, the handle is lengthened by a wooden spring, bent to a bow three or four feet long, which at the other extremity rests against a fixed point to a beam placed above. The plate is now fastened to a table with plaster, covered with colcothar, and the polisher begins his operation by working it backwards and forwards over the surface of the plate till one side is done; then the other is to be polished in the same manner.

To silver glass-plates a flat slab of wood or free-stone is used; on this is placed a sheet of paper, on which is spread, as smooth as possible, a sheet of tin-foil a little larger than the plate: mercury is now thinly spread over the tin-foil, and then the glass-plate is to be drawn over the mercury just to skim off the upper surface, and being let go it sinks on the tin-foil, squeezing out the superfluous mercury, which flows off in a channel made in the slab for the purpose. The plate is then covered with a thick flannel, and heavy leaden or iron weights, which in a day or two cause the mercury and tin-foil closely to adhere to the glass.

About

About the autumn 1805, Mr. William Scott obtained a patent for improvements in the manufacturing and working various kinds of glass. According to the specification enrolled in Chancery, the object of the invention was to grind and polish glass of a thinner substance than had been hitherto practised, by flashing or expanding it in the process of manufacturing, by a rotative motion, in a similar manner to window glass, preserving such thickness in the blowing as may be deemed necessary. When drawn from the annealing kilns, they are to be cut into squares, placing two, three, or more upon each other in spreading or annealing kilns, upon flat surfaces of stones, glass, or other substances, and producing such degree of heat as will cause the glass to give or yield to the surface thus placed upon, thereby becoming flat, and adapted for grinding, rendering such fit for silvering. Also to grind and polish sheet-glass by flattening, and by buckling, tying, or fixing such to beds of plaster, for grinding and for polishing.

Compositions for White and Crystal Glass.

To make *crystal-glass,* take of the whitest tarso, pounded small, and sifted as fine as flour, two hundred pounds; of the salt of polverine one hundred and thirty pounds; mix them together, and put them into the furnace called the calcar, first heating it. For an hour keep a moderate fire, and keep stirring the materials with a proper rake, that they may incorporate and calcine together; increasing the fire for five hours; after which the matter is taken out, being sufficiently calcined, and is called *frit*. After this, remove it immediately from the calcar to a dry place, and cover it up from dust, for three or four months. Now, to make the crystal glass, take of the above crystal frit, called also *bollito,* and set it in the melting pots in the furnace, adding to it a due quantity of manganese; when the two are fused, cast the

flour into fair water, to clear it of the salt called *sandiver*, which would otherwise make the crystal obscure and cloudy. This washing must be repeated again and again, till the crystal be fully purged; or this scum may be taken off by proper ladles. Now set it to boil for four, five, or six days; which being finished, see whether it have manganese enough; and if it be yet greenish, add more manganese, at discretion, by little and little at a time, taking care not to over dose it, because it will incline it to a blackish hue. Let it clarify, and become of a shining hue; which done, it is fit to be used, and blown into vessels of any kind. *Or,*

120 parts of fine sand; 40 of purified pearl-ash; 35 of litharge; 13 of nitre; and a small quantity of black oxyde of manganese.

Compositions for Flint-Glass.

FLINT-GLASS, as it is usually called by us, is of the same general kind with that which in other places is called crystal glass. It has this name from its having being originally made with calcined flints, before the use of white sand was understood; and it has retained this name, though there are now no flints used in its composition. This glass differs from the crystal glass, in having lead in its composition, to flux it, and white sand for its body; whereas the fluxes used in the other are salts, or arsenic, and the body consists of tarso, white river pebbles, and such stones. To the lead and white sand a due proportion of nitre is added, and a small quantity of magnesia. The most perfect kind of flint-glass is made by fusing, in a very strong fire, one hundred and twenty pounds of white sand, fifty pounds of red-lead, forty pounds of the purest pearl-ash, twenty pounds of nitre, and five ounces of magnesia. Another composition of flint glass is said to be the following: one hundred and twenty pounds of white sand, fifty-four pounds of the purest pearl-ash, thirty-six pounds of

 red-

red-lead, twelve pounds of nitre, and six ounces of magnesia. To either of the above compositions, a pound or two of arsenic may be added, to increase the flux of the composition. A still cheaper flint-glass may be made with one hundred and twenty pounds of white sand, thirty-five pounds of the best pearl-ash, forty pounds of red-lead, thirteen pounds of nitre, six pounds of arsenic, and four ounces of magnesia; or, instead of the arsenic may be substituted fifteen pounds of common salt; but this will make it more brittle than the other. But the cheapest of all the compositions hitherto employed, consists of one hundred and twenty pounds of white sand, thirty pounds of red-lead, twenty pounds of the best pearl-ash, ten pounds of nitre, fifteen pounds of common salt, and six pounds of arsenic. *Or,*

100 parts of sand, 80 to 85 of red-lead, 35 to 40 of pearl-ash, two to three of nitre, and one ounce of manganese. The oxyde of lead may be reduced in this glass. If hydrogen gas be passed through a red-hot tube of it, the inner surface will become black with the reduced lead.

A harder Glass than the foregoing.

TAKE four ounces of borax, and an ounce of fine washed white sand; reduce both to a subtil powder, and melt them together in a large close crucible, set in a wind furnace, keeping up a strong fire for half an hour; then take out the crucible, and let it grow cold, and break it, and there will be found at the bottom a pure hard glass, capable of cutting common glass like a diamond. It is observed, that time makes a sensible impression on glasses in which borax makes too great an ingredient.

To make Crown-Glass.

TAKE 200 parts of soda, 300 of fine sand, 33 of lime, and from 250 to 300 of the ground fragments of glass.

To make Plate-Glass.

TAKE 300 parts of sand, 200 of soda, 30 of lime, 32 of manganese, three of azure, and 300 of fragments of glass.

To calcine Brass, which in Glass makes a Sky or Sea-green.

BRASS is copper mixed and fused with *Lapis Calaminaris,* which not only changes it into a gold colour, but increases its weight; this mixture gives a sea-green or sky-colour to glass, when it is well calcined; and to do this, observe the following rules:

Take brass plates, and cut them into small slips, and put them into a crucible; cover and lute it well, and give it a reverberatory fire in a furnace, yet not a melting one, for if it melts, all your labour will be lost: let it stand in that heat for four days, by which time it will be well calcined; then beat it to an impalpable powder and sift it; grind it fine on a porphyry, and you will have a black powder; spread it on tiles, and keep it on burning coals, or the round hole of a furnace, for four days; clear it of the ashes that have fallen upon it, pulverize and sift it, and keep it for use. To try whether it is calcined enough, fling a little into melted glass, and if it swells, the calcination is enough, but if not, then it is either not calcined enough, or else it is burned, and will not colour the glass so well as when the calcination is perfect.

To calcine Brass after another Manner, for a transparent Red Colour, or a Yellow.

Cut your brass into small shreds, and lay it *stratum super stratum* in a crucible, with powdered sulphur; set it on a charcoal fire in a furnace for 24 hours, then powder and sift it: when this is done, put it covered into the furnace hole, for 10 hours, to reverberate, and when cold, grind it again very fine, and keep it for use.

General Observations for all Colours.

1. All the melting pots must be glazed with white glass on the inside; for a new earthen pot that is unglazed will cause the colours to look bad and foul; but the second time of using these pots they lose their foulness.

2. Observe that these pots serve for one colour only, and may not be used for another: every colour must have its own pot.

3. Let the powders be well calcined; neither too much nor too little.

4. Your mixtures must be made in due proportion, and the furnace must be heated with hard and dry wood.

5. You must use your colours divided: one part you must put in the frit before it is melted, and the other after it is melted and become fine and clear.

To make Glass of Lead, which is the fittest for receiving of most Colours.

Take of calcined lead 15 pounds; of rochetta, or pulverized crystal frit, 12 pounds; mix them well, and put them

them together into a melting pot, then into a furnace, and, at the end of ten hours, cast them into water: clear the melting pot of the lead that remains, and return the metal into it, which, after 10 hours heat, will be fit to work with. Before you take it upon the iron, raise the glass first in the pot a little, then take it out to let it cool for a small space of time, after which work it on a clean and smooth iron plate.

Blue Glass.

Take four ounces of calcined and pulverized rock crystal, two ounces of nitre, one ounce of borax, half a pound of of manganese, one pound of indigo-blue.

A Chrysolite Glass.

To one pound of frit; take pulverized verdigrise three ounces and a half, red-lead one ounce.

A Sapphire Green Glass.

To one pound of the above composition, or crystal frit, take one ounce of good zaffre, and of very fine pin-dust two pounds.

To make fine Green Glass of Tin.

Take the filings, or shavings of tin, nine parts; dissolve them in aqua-fortis; sweeten the calx with clean spring water; then take 18 parts of nine-times calcined antimony: its calcination must be repeated until it has done evaporating. Both these melted together, make a fine crysolite or emerald.

This

This glass will melt upon silver, like enamel, and may be used, on several occasions, for such things as are proper for ornaments.

To make a Ruby-coloured Glass.

Take good aqua-regia four ounces; fling into it, by little and little, thin bits, or filings of tin, one ounce, and let it dissolve: take the finest gold, as much as you will, and dissolve it in aqua-regia: take a clean glass with clear spring-water, and pour the solution of the gold, as much as you please, into it; the same quantity put also to it of the solution of the tin, and the water will turn to a fine rose colour; with this water moisten several times your glass frit; or let the purple colour subside, and then pour off the liquor, and use the dry powder only. This powder is of various tints of purple, and is the more valuable in proportion to the intensity. Then proceed as you do with other glass in fire; at first it comes out white, but afterwards becomes a fine ruby.

THE ART OF GLASS IN MINIATURE.

The Art is performed by the Flame of a Lamp, in the following Manner.

First, provide yourself from the glass-house with several pipes of glass, that are hollow, of several colours, and different sizes: then you must have a table, as you see represented at fig. 3, plate 6. A is the artist, who is furnished with a

lamp

lamp and oil, or with tallow, and a large wick of twisted cotton; below the table is a pair of bellows, B. When the artist treads the treadle fastened to the bellows, the wind will be conveyed through the pipes under the table to the small opening by C C, directly in which are placed the lighted wicks of the lamps. The smoke which issues forth from the lamp, is conveyed through a broad funnel made of tin or wood, E.

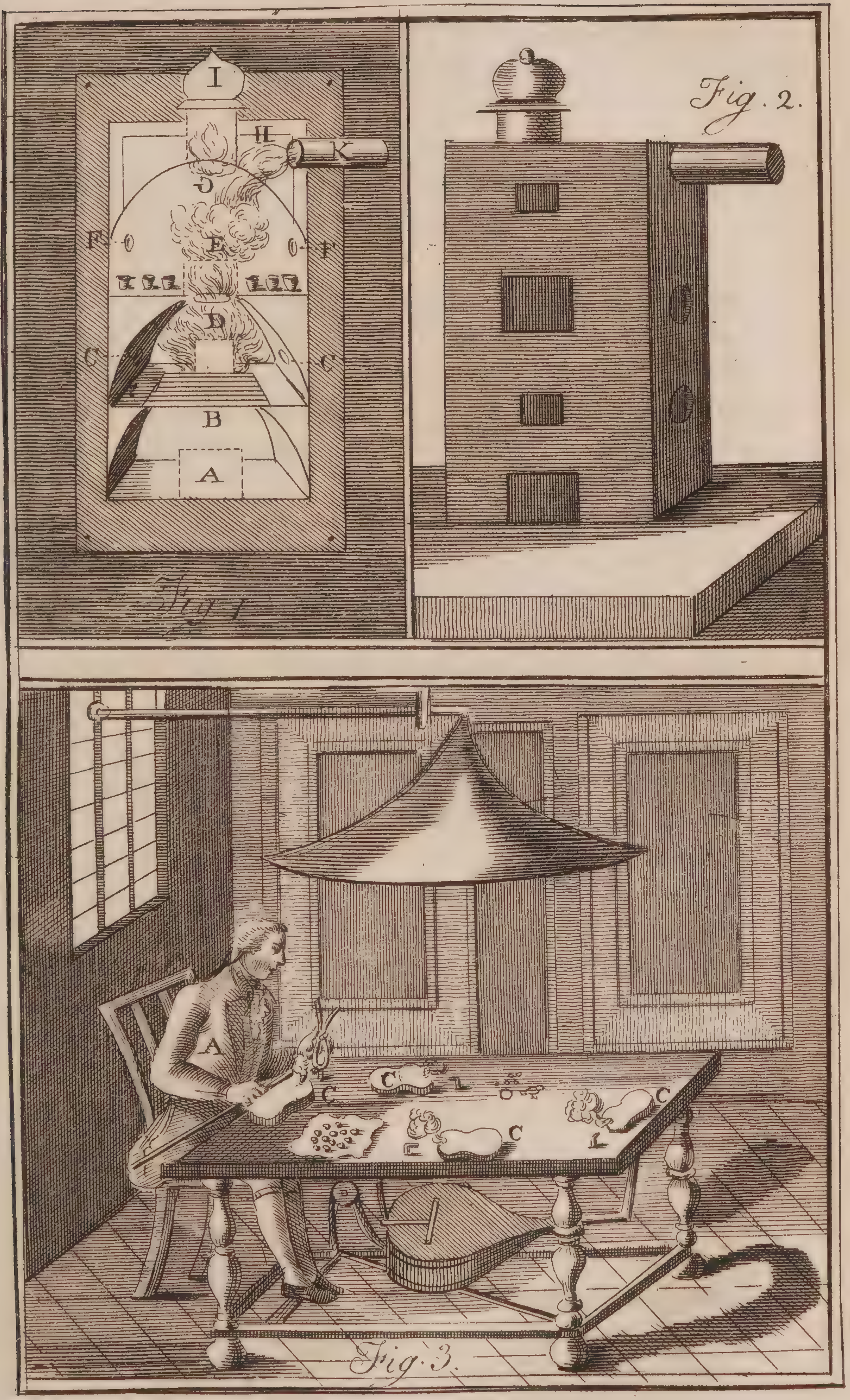
The wind, which strikes in a sharp point against the flame, occasions such a violent heat that it will dissolve the most stubborn glass, and you may, after you have softened the end of your pipe in the flame, blow through the hollow, and form, with small plyers and other useful tools, whatever you please: small twisted nooses of wire are very convenient to hold your work in, in order to shape and join different colours to one piece. The whole art depends chiefly upon practice.

The usefulness of such a table answers several other purposes; as, for trying of metal ore: in this case put some of it in a hollow piece of charcoal, &c. and by directing the wind, by means of a blow-pipe, through the lamp upon the ore, the heat will melt it immediately, and shew what it contains. In soldering, it is also very convenient; not to mention the conveniency which such a table affords to practitioners in chemistry.

It is likewise convenient for the structure of small articles of glass intended for philosophical purposes. By this means glass may be spun out into threads of almost indefinite minuteness. When about the size of the human hair, it is extremely elastic and flexible; and if still finer, it may be wound on a reel, like thread, without fear of breaking. The mode of working it is this: a piece of glass tube is heated in the lamp, and the end drawn out into a thread by means of another piece of glass cemented to it. When a fine thread is once drawn, the end is carried round a reel two or three feet in diameter, and by turning the wheel, and continuing

to

PLATE · 6.



to the heat the tube, an almost endless thread is drawn out, winding round it as long as the artist pleases.

How to lay Silver on Glass Utensils, Plates, Dishes, Salts, Drinking Cups, &c.

TAKE of pure silver what quantity you please, and beat it very thin; then put it into a matrass, and pour twice its weight of aqua-fortis upon it, and you will presently perceive the silver dissolve: when you observe its ceasing to work, put your matrass on warm sand or ashes, and it will begin to work afresh; let it thus stand till all your silver is dissolved. After this pour the solution out of that matrass into another, and evaporate a little, and let the matrass remain on the sand till it is cool; then take it off, and let it stand for twenty-four hours, and the silver will shoot into white crystals; from these pour off the solution which remains, and evaporate again the half of the liquor; then set it, as before, to crystallize; this repeat, till all the silver is turned into crystals: take them out of the glass, lay them upon whited-brown paper to dry, and preserve them for use.

Of these crystals take as much as you will, and put them into a matrass, and pour upon them two or three times their weight of the strongest spirit of sal-ammoniac; lute it well, and put it into a gentle warmth for eight or ten days to digest, and it will contract a blue colour; pour it off, filter it, and evaporate in a sand-bath a little, and there will remain a glass-green liquid; with this melt your glass, and put it into a glass furnace, or into any gentle heat; your glass will look as if it were silver plate.

But in case there should be an oversight, and the spirit of sal-ammoniac be too much drawn off, and the silver turned to a green salt, then pour as much of that spirit upon the silver again as will bring it to a green liquid.

A curious

A curious Drinking Glass.

Take two smooth drinking glasses, fitted close to each other, so that the brims of both may be even; then paint on the inside of the larger glass with oil colours, what you will, either in imitation of mosaic, or any other invention; and when dry, you may with the point of a needle open fine veins or other embellishments, &c. Then oil it all over with old linseed oil; and before it is quite dry, whilst clammy, lay leaf gold upon it; press it close down to the glass with cotton, and let it dry thoroughly. In the mean while, take the other lesser glass, and lay a thin clear varnish on the outside, and when almost dry, lay on leaf gold, and the inside of the glass will look all over gilded. When this is dry, put it into the larger glass, and make a paste of chalk and lack varnish, with this, lute the rims of the two glasses, so that it may not be perceived, but look as if it were made out of one piece; let it thoroughly dry, and give it another layer of lac varnish, with a fine pencil, and let it dry; then smooth it with pumice stone, and lay on it a thin varnish; and when that is almost dry, gild it with leaf gold, and give it two or three layers of lac varnish, and the gold will remain firm.

Instead of painting with oil colour, if you only anoint the inside of the glass with linseed oil, and then strew it over with spangles, and put the inside glass gilded, to join, it will have a singular beauty. This hint will animate the ingenious to try farther experiments of this amusing kind.

How to Quicksilver the inside of Glass Globes, so as to make them look like Looking-glass.

Take two ounces of quicksilver, one ounce of bismuth, of lead and tin half an ounce each.

First

First put the lead and tin into fusion, then put in the bismuth; and when you perceive that in fusion too, let it stand till it is almost cold, and pour the quicksilver into it.

After this, take the glass globe, which must be very clean, and the inside free from dust; make a paper funnel, and put it in the hole of the globe, as near to the glass as you can, so that the amalgam when you pour it in, may not splash and cause the glass to be full of spots; pour it gently, and move it about, so that the amalgam may touch every where. If you find the amalgam begin to be curdly, and to be fixed, hold it over a gentle heat, and it will flow easily again. If you find the amalgam too thin, add a little more lead, tin, and bismuth to it. The finer and clearer your globe is, the better will be the looking-glass.

THE ART OF PAINTING UPON GLASS.

This noble art being the admiration of all who have any tolerable taste of designing or painting, it will not be improper to give the ingenious enquirer after this mystery some few hints, not only to satisfy his curiosity with its nature, but also, if he be inclined, to lead him into the practice of it; which we shall do in the plainest and shortest manner possible.

First then, chuse such panes of glass as are clear, even, and smooth.

2. Strike one side of each pane with a clean spunge, or a soft hair pencil, dipt in gum-water, all over.

3. When it is dry, lay the clean side of the glass on the outlined design you intend to copy, and with a small pointed pencil (furnished with black colour, and prepared for that purpose, as shall be directed) delineate the outlines, or capital strokes; and where the shades appear soft, work them by dotting, and easy strokes, one into another.

4. After

4. After you have finished your outlines and shades in the best manner you are able, take a larger pencil, and lay on your colours in their respective places; as a carnation in the face, hands, &c. green, blue, red, or any other colour on the drapery, &c.

5. When you have done this, heighten the lights of your work carefully with an unsplit stiff pen, with which take off the colour, by way of etching, in such places where the light is to fall strongest, and where it is of use to give the beard, or hair, a graceful turn.

6. You may lay all sorts of colours on the same side of the glass you draw your design upon, except yellow; which lay on the other side, in order to prevent its flowing and mixing with other colours, and spoiling your work.

Necessary Observations in the baking of Glass, or burning in the Colours, after it is painted.

YOUR furnace for baking painted glass must be built square, with three divisions. The lower division is for receiving the ashes, and for a draught for the fire.

The middle division is for the fire, which has an iron grate below, and three iron bars cross the top, to set the square earthen pan upon, which contains the painted glass.

The third division has the aforementioned bars at the bottom, and a lid at top, in which are five holes for the smoke and flame.

The earthen pan is made of good potters clay, according to the shape and dimensions of the furnace, about five or six inches high, with a flat bottom. It must be fire proof, and no larger than to have at least two inches space all round, free from the sides of the furnace *.

* Such is the extreme simplicity of the art, and the high value it bears, that it is wonderful so few artists have turned their talents towards it. It is, however, carried to high perfection by Mr. Pearson, of Highgate.

When

When you are going to bake your glass, take quick-lime, which previously has been well nealed, or made red-hot in a fierce coal fire: when cold, powder it, and sift it through a small sieve, as even as you can, all over the bottom of the pan, about half an inch thick; then with a smooth feather wipe it even and level; when this is done, lay as many of your painted glasses as there is room. This continue till the pan is full, sifting upon every layer of glass a layer of the mixed powder, very even, about the thickness of a crown piece. Upon the uppermost layer of painted glass, let the layer of powder be as thick as the bottom. Put the pan, thus filled to the brim, upon the iron bars in the middle of the furnace, and cover the furnace with a cover made of potter's earth; lute it very close all round, to prevent any vent but what comes through the holes of the cover. After you have ordered the furnace in this manner, and the luting is dry, make a slow charcoal, or dry wood, fire, at the entrance of the furnace; increase it by degrees, lest by a too quick fire the glass should be subject to crack; continue thus to augment your fuel, till the furnace is full of charcoal, and the flame conveys itself through every hole of the cover: keep thus a very violent fire for three or four hours, and then you may draw out your essays, which are pieces of glass on which you have painted some yellow colour, and placed against the pan; and when you see the glass bended, and the colour melted, and of a qualified yellow, you may conclude that your work is near done; you may also perceive by the increase of the sparklings of the iron bars, or the light streaks on the pan, how your work goes on. When you see your colours almost done, increase the fire with some dry wood, and put it so that the flame may reverberate all round the pan: then leave the fire, and let it go out, and the work cool of itself. Take it out, when quite cold, and with a brush clear your glass gently from the powder that may lie upon it, and your work is done.

The

The colours in use for painting upon glass, are next to be treated of, and are as follows:

For Black Colours.

Take scales of iron from the anvil, fourteen ounces and a half; mix with it two ounces of white glass, one ounce of antimony, manganese half an ounce; grind them with good vinegar to an impalpable powder. *Or,*

Take scales of iron one part, and rochetta one part, grind them together very fine upon an iron plate, for one or two days; when they begin to be tough, and look yellowish, and clog to the muller, it is a sign that it is fine enough. *Or,*

Take one pound of enamel, three quarters of a pound of copper flakes, and two ounces of antimony, grind them as before directed. *Or,*

Take glass of lead three parts, copper flakes two parts, and one part of antimony, proceed therewith as before.

A Brown Colour.

Take one ounce of white glass, or enamel; half an ounce of good manganese; grind them first with vinegar very fine, and then with brandy.

A Red Colour.

One ounce of red chalk, ground, and mixed with two ounces of ground white enamel and some copper flakes, will make a good red; you may try, with a little, whether it will stand the fire, if not, add some more copper flakes to it. *Or,*

Take

Take red chalk, that is hard and unfit to draw with, one part; of white enamel one part; and one-fourth part of orpiment; grind them well together with vinegar; and when you use them, avoid the smoke, which is poisonous.

A Blue Colour.

Take *Burgundy* blue, or blue verditer, and lead glass, an equal quantity; grind them with water to a very fine powder, and when you use them, lay the flowers that are to be of a blue colour, all over therewith; then raise the yellow parts opened, with a pen, and cover them with a yellow glass colour: observe, that blue upon yellow, and yellow upon blue, always make a green.

A fine Yellow Paint for Glass.

It has been found by experience, that the best yellow for painting upon glass, is prepared of silver; wherefore, if you would have a fine and good yellow, take fine silver, beat it into thin plates, and dissolve and precipitate it in aqua-fortis, as has been directed; when it has settled, pour off the aqua-fortis, and grind the silver with three times the quantity of well burned clay from an oven, very fine; and with a soft hair pencil lay it on the smooth side of the glass, and you will have a fine yellow.

A pale Yellow.

Stratify thin plates of brass in an earthen pipkin with powdered sulphur and antimony, and burn them until it yields no more flame; then pour them red hot into cold water; take out this and grind it fine. Of this powder one part;

part; of yellow ochre, after it is nealed and quenched in vinegar, five or six parts; let it dry; then grind it on a stone, and it will be fit for use.

How to deaden the Glass, and fit it to paint upon.

TAKE two parts of iron flakes; one part of copper flakes, three parts of white enamel; grind them all together, with clear water, on a marble stone, or upon a brass or iron plate, for two or three days, as finely as possible; with this rub your glass well over, especially that side you draw your design upon, and you will finish your work much neater.

Some general Observations on the Management of painting and baking of Glass.

FIRST, when you lay your glass in the pan, let the painted side be placed undermost, and the yellow upermost.

2. Dilute all your colours with gum-water.

3. Grind the black and red upon a copper-plate; other colours you may grind on a piece of glass, or a stone.

4. Glass-colours ready prepared are, glass enamel, which is brought from *Venice* in cakes of several sorts; also the small glass beads that are brought over from *Germany*, especially from *Francfort* on the *Main*. Old broken pieces of painted glass are good for that purpose; so is the green glass of potters, and the glass drops that run from the ware in the furnace.

5. The colours which are used by potters for painting on earthen ware, may also be used for painting on glass.

OF

OF POTTERY AND PORCELAIN: AND THE ART OF GLAZING AND PAINTING ON FINE EARTHEN-WARE, COMMONLY CALLED DELFT WARE.

The essential material of pottery and porcelain is clay, which (1.) is so plastic that with water it becomes a soft uniformly extensible mass, capable of retaining any form: (2.) When it is thoroughly dried, and has undergone a red heat for a time, it loses its plasticity, becomes hard, close in its texture, and more or less capable of retaining any liquids within its hollow. The plasticity of clay is owing to its alumina; but there are clays sufficiently mixed with other substances for the purposes of the potter without any addition. The finer and purer clays, however, require a mixture of silica before it can be used in the manufacture. The texture, including the qualities of hardness and compactness, depends partly on the mixture of the siliceous ingredient with the clay, and partly on the heat employed in the burning. The purer natural clays are almost infusible in any furnace heat, their hardness is nearly progressive with the intensity of the fire, but then they are apt to shrink in drying. On this account it is necessary to mix them intimately with some earth that possesses qualities opposite to those of clay, that is, which absorbs but little water and readily parts with it, and which dries compact and close.

The fusibility of clays and other pottery earths, is a subject of much importance, as on this the distinction between pottery and porcelain chiefly depends. Porcelain has been defined a species of pottery, which resists complete fusion in a very considerable heat, but has been brought by a less heat than its melting point to a state of incipient fusion, and thereby acquired extreme hardness, sonorousness, semi-transparency, and a fracture approaching to the vitreous. This last is a distinctive character between porcelain and pottery,

pottery, for the fracture of the latter is simply granular. Hence it has been inferred, that no chemical action takes place in any pottery mixture, till it arrives at the state of porcelain. The manufacture of the ordinary pottery is very simple. There must be an intimate mixture of the ingredients used, because on this depend the beauty, the compactness, and soundness of the ware. The materials are first brought to an impalpable powder, and mixed with water till they are brought to the consistence of cream, after which the superfluous water is suffered to evaporate, till the mass is brought to a due consistence.

In the manufacture of common Staffordshire ware, the clay used is brought from Devonshire, and a siliceous stone, called "chert," or common flint, reduced to powder by heating red-hot, suddenly quenching it in water, and then grinding it to a subtle powder. Each material is passed through fine brass sieves, then diffused in water, mixed by measure, and brought to a plastic state. The workman takes a lump of this, and with the aid of his wheel, and an iron blade, he fashions it into the shape required, after this it is moulded on a plaster model. Handles, spouts, or ornaments, are then stuck on, and the articles set to dry in a warm room. When sufficiently dry, they are enclosed in clay cases, called "seggars," and placed in the furnace or kiln to be baked. Some kilns will hold twenty or thirty thousand pieces of pottery. In this state the ware is called biscuit: it is perfect pottery, very hard and white, with a tint of yellow; its surface is smooth, but without gloss.

Glazing is the next process, for which purpose the biscuit is dipped in a tub containing a mixture of litharge, clay, and ground flint, in the proportions of 60, 10, and 20, diffused in water to a creamy subsistence, and when taken out enough adheres to the piece to give it an uniform glaze when heated. They are again packed up in the seggars, with small bits of pottery interposed between them, and placed in the kiln as before. The glazing mixture fuses at a very moderate

moderate heat, and gives an uniform glossy coating, which finishes the process for common white ware.

The finest kind of stone-ware, called porcelain, does not differ essentially from common stone-ware; but it is more beautiful and more capable of resisting the action of chemical agents, on account of the purity of the substances of which it is composed, and the nature of the enamel with which it is covered. It was early brought to a state of considerable perfection in China and Japan, but the discovery of the art of making it in Europe is of a much later date. Specimens of it were brought first from China and Japan to modern Europe. Various attempts were made to imitate them in different countries of Europe, but the greater number were without success. Accident led to the discovery in Germany, about the beginning of the 18th century. A chemist, during a set of experiments, in order to ascertain the best mixtures for making crucibles, stumbled upon a compound, which yielded a porcelain similar to that of Japan. In consequence of this discovery, Saxony soon produced porcelain scarcely inferior to that of Japan in beauty, and superior to it in solidity and strength; but its composition was kept a profound secret; nor were there any accurate ideas respecting the component parts of porcelain, till Reaumur published his dissertations on the subject in 1727 and 1729. That celebrated philosopher examined the porcelain of Japan, and the different imitations of it which had been produced in France and other parts of Europe. The texture of the first was compact and solid, but that of the imitations was porous. When both were exposed to a strong heat, the first remained unaltered, but the others melted into glass. From these experiments he inferred, that Porcelain owes its semitransparency to a kind of semivitrification which it has undergone. It may receive this two ways:—1. Its component parts may be such as easily vitrify when sufficiently heated; but the degree of heat given may be just sufficient to occasion a commencement only of vitrification. This

 porcelain,

porcelain, when strongly heated, will easily melt. Such, therefore, was the composition of the European porcelain. 2. It may be composed of two ingredients; one of which vitrifies, but the other is not altered by heat. When a porcelain, composed of such materials, is baked in a sufficient heat, the fusible part melts, envelopes the infusible, and forms a semitransparent substance, which is not farther altered by the same degree of heat. Such, therefore, must be the porcelain of Japan. The ingredients made use of in China are a hard stone called "petunse," which they grind to powder, and a white earth called "kaolin," which is intimately mixed with it. Reaumur found the petunse fusible, and the kaolin infusible, when exposed separately to a violent heat. In 1758, the Count de Lauragais, assisted by Darcet and Le Gay, began a set of experiments which were continued for four years, and which led to the discovery of a porcelain possessed of the same qualities with that of China, and inferior only in whiteness. Macquer, who at that time superintended the manufactory of Sevres, advised the French government to propose a reward for the discovery of earthy substances capable of forming a white porcelain. This was done; and in consequence of it, Villaris, an apothecary of Bourdeaux, announced the existence of a white earth near Saint-Yriex-la-Perche, in the department of the Haut-Vienne, which would answer the purpose. It was tried by Macquer with the expected success, and a porcelain manufactory was established at Sevres. Different manufactures of porcelain have been successfully established likewise in England; first at Chelsea, in the neighbourhood of London, and afterwards in Colebrookdale, and in Derby. The essential ingredient of porceleain is a very pure clay known by the name of porcelain-clay. This is equivalent to the kaolin of the Chinese. Sometimes porcelain-clay consists of materials mixed in such proportions that no addition is necessary; the biscuit made from it being susceptible of undergoing that semivitrification which gives the transparency and compact nature that distinguish

tinguish porcelain. Such is the porcelain-clay of Limoges.

The porcelain-clay of Cornwall, which does not acquire transparency without addition, yielded to Mr. Wedgewood

60 alumina,
20 silica,
12 moisture,
8 loss.

100

Giobert has announced, that porcelain-earth is sometimes nearly pure magnesia and silica. When an addition is necessary, the substance used is felspar, which is equivalent to the petunse of the Chinese. According to a German writer, the finest Saxon porcelain is formed by mixing together equal weights of ground felspar and porcelain clay. The method of forming the biscuit of porcelain is the same as of stone-ware, already noticed, and therefore requires no particular description. Porcelain is always covered with a glaze, composed of earthy ingredients, without any mixture of metallic oxydes. Hence the high temperature necessary to fuse it, and the property which porcelain vessels have of resisting the action of the most corrosive substances precisely as common glass does. The substance commonly employed is felspar; which is composed essentially of silica and alumina united to some potash, to which the fusibility is to be ascribed. This is the glaze said to be used in Saxony, and likewise at the manufactory of Sevres, near Paris. Vessels both of stone-ware and porcelain are commonly painted of various colours. These paintings are often excellent, both in elegance of workmanship and in brilliancy of colours. The colours are given by means of metallic oxydes, which are mixed up with other ingredients proper to constitute an enamel, and applied in the usual manner with a pencil. On this subject much light has been thrown by the experiments of Wedgewood; and Broguiart has lately published a general

accoun t

account of the processes at Sevres, of which he is director. The process differs a little according to the substance on which the colours are to be applied. When the vessels are covered with enamel, less flux is necessary, because the enamel melts at a low heat, and the colours readily incorporate with it. But this renders them more dilute, and makes it often necessary to retouch them. The colours on enamel generally appear brilliant and soft, and are not liable to scale. The flux is either a glass of flint and lead, or borax mixed with flint-glass. The colours are usually made into a paste by means of gum-water or volatile oils. The colours applied upon hard porcelain, or porcelain glazed with felspar, are nearly the same as those applied on enamel, but more flux is necessary. They are not liable to dilution, as the felspar glaze does not melt at the heat requisite for fusing the colours and their flux. Colours are sometimes applied over the whole surface of the porcelain; the flux in that case is felspar. But such colours are not numerous, because few oxydes can stand the heat necessary for melting felspar without being themselves altered or volatilized. Purple is given by means of the purple oxyde of gold precipitated by a small quantity of muriate of tin. This oxyde is mixed with a quantity of powdered glass, borax, and oxyde of antimony, and applied with a pencil. It will not bear a strong heat without losing its colour. Red is given by oxyde of iron. A mixture of two parts of sulphate of iron and one part of alum is calcined slowly, till it acquires a fine red colour. This powder is mixed with the flux, and applied with a pencil. Yellow is given by the oxyde of silver, or by oxydes of lead, antimony, and sand; green, by the oxyde of copper; blue, by the oxyde of cobalt; and violet, by the oxyde of manganese. Gilding upon porcelain is performed in the same way as painting. The gold is reduced to the state of an impalpable powder by solution and precipitation. It is mixed up to the proper consistence with oil and a small quantity of flux, and applied with a pencil; the vessels are baked

a second

a second time. By this the gold is made to attach itself firmly to the vessel, and by the burnisher it acquires the requisite lustre. Painting common stoneware vessels would enhance their price too much; but this is avoided by an ingenious mode of copper-plate printing, said to have been first invented in the neighbourhood of Liverpool. The figure which is to be painted on the vessel is engraven on a copper-plate in the usual way, excepting only that it is not reversed, as is done in common copper-plate engraving. The paint to be applied to the stone-ware is brought to the requisite consistence, put upon the copper-plate, and the impression taken off, as usual, upon moist paper, by means of the rolling press. The paper, while still moist, is applied to the stoneware biscuit, and pressed upon it. By dipping the biscuit in water, and agitating gently, the paper is washed off without injuring the impression upon the vessel, the paint having been made up with oil. The impression upon the paper was reversed; but upon the stone-ware it is precisely as it was cut upon the copper-plate. The vessel being now baked, the paint is glazed on, and assumes its colour and brilliancy. By this contrivance any number of vessels may be easily printed with the same figures in a very short time. This ingenious process seems to be at present confined to Britain.

We shall now set down some receipts that chiefly relate to the glazing of earthen-ware.

How to prepare the Clay for Delft *Ware.*

TAKE one part of calcined flint, one part of chalk, and one part of capital, or the cream of clay; mix and work them well to a proper consistence.

To

To prepare a White Glazing.

TAKE of lead two pounds, and of tin one pound; calcine them to ashes, as has been directed before. Of this take two parts; calcined flint or pebble, one part; salt, one part; mix them well together, and melt them into a cake.

The Rotterdam *fine shining White.*

TAKE of clean tin ashes two pounds, lead ashes ten pounds, fine *Venice* glass two pounds, tartar half a pound; melt them into a cake. *Or,*

Lead ashes eight pounds; tin ashes three pounds; fine clear calcined flint, or pebble, six pounds; salt four pounds: melt them into a cake. *Or,*

Calcine eight pounds of lead, and four pounds of tin, into ashes; of these take one quart, salt and pebble of each one pound; melt them into a cake.

Another fine White for Earthen-Ware.

CALCINE six pounds of lead, and three pounds of tin, to ashes; whereof take two parts, salt three parts, pebble or flint three parts; melt them into a cake.

Another White.

TAKE eight pounds of lead, and four pounds of tin ashes; among which mix six pounds of *Venice* glass, and a handful of rock-salt: melt them into a cake.

Saltzburg *White.*

TAKE three parts of lead, and six parts of tin; or six parts lead, and three parts tin; salt three parts; tartar one part; and pebble five parts, &c. *Or,*

Take five pounds of lead, one pound of tin, three pounds of flint, three pounds of salt, &c. *Or,*

Take six pounds of lead, and one pound of tin; melt and burn them to ashes; whereof take twelve spoonfuls, twelve of flint, and twelve of fine wood ashes.

To lay a Ground upon Earthen-Ware, on which the White Glass will spread the better.

TAKE calcined tartar one pint, and flint and salt, of each one pint; mix them together, and use them for a layer, or ground, over your earthen-ware, before you glaze them.

The common Ware is thus glazed.

TAKE forty pounds of clear sand, seventy-five pounds of litharge or lead ashes, twenty-six pounds of pot ashes, and ten pounds of salt; melt them three times into a cake, quenching it each time in clear cold water. *Or,*

Take clean sand fifty pounds, lead ashes seventy pounds, wood-ashes thirty pounds, salt twelve pounds: melt them to a cake.

With this mixture they glaze fine and coarse, and set it in an earthen glazing pan, which is round: the ware is set in them, upon three-cornered bars that go through the like holes in the pan, and the ware is kept asunder from touching one another: the pan must be entirely closed up.

COLOURS

COLOURS FOR POTTER'S GLAZE-WORK.

A fine Yellow.

TAKE red-lead three pints; antimony and tin, of each two pounds; melt them into a cake; grind it fine, and melt it again. Repeat this several times, and you will have a good yellow. *Or,*

Take fifteen parts of lead ore, three parts of pale litharge, and fifteen parts of sand. *Or,*

Take eight parts of litharge, nine parts of calcined flint, one part of antimony, and a little iron filings; calcine and melt them to a cake.

A fine Citron Yellow.

TAKE six parts of red-lead, seven parts of fine red brick-dust, two parts of antimony; melt them to a cake.

A Green Colour.

TAKE eight parts of litharge, eight parts of *Venice* glass, four parts of brass dust; melt them for use. *Or,*

Take ten parts of litharge, twelve parts of flint or pebble, one part of *æs ustum,* or copper ashes.

A Blue Colour.

TAKE lead ashes one pound, clear sand or pebble two pounds, salt two pounds, white calcined tartar one pound; *Venice* or other glass, sixteen pounds; zaffre half a pound;

mix

mix them well together, and melt them; quench them in water, and melt them again; repeat this several times: but if you will have it fine and good, it will be proper to put the mixture into a glass furnace for a day or two. *Or,*

Take litharge four pounds, clear sand two pounds, zaffre one pound; calcine and melt it together. *Or,*

Take twelve pounds of lead, one pound of tin, and one pound of zaffre, five pounds of sand, and three pounds of salt; tartar and glass one pound; calcine, and melt into a cake. *Or,*

Take two pounds of litharge, a quarter of a pound of sand, one pound of zaffre, and one pound of salt; melt them as directed. *Or,*

One part of tartar, one part of lead ashes, one part of zaffre, one part of sand, and two parts of salt; melt as before.

A Brown Colour.—Take of common glass and manganese, of each one part; lead glass twelve parts.

A Flesh Colour.—Take twelve parts of lead ashes, and one of white glass.

A Purple Brown.—Take lead ashes fifteen parts, clear sand eighteen parts, manganese one part, white glass fifteen measures, and one measure of zaffre.

An Iron Grey.—Take fifteen parts of lead ashes, fourteen parts of white sand, five parts of copper-ashes, one of manganese, one of zaffre, and one of iron filings.

A Black.—Take lead ashes eighteen measures, iron filings three, copper ashes three, zaffre two; this, when melted, will make a brown black; but if you will have it blacker, put some more zaffre to it.

A Brown on White.—Manganese two parts, red-lead and white glass one part; melt them well together.

A fine Red.—Take antimony two pounds, litharge three pounds, rust of iron calcined one pound; grind it to a fine powder.

To

To glaze with Venice Glass.—When your ware is well dried, and ready to bake, strike it all over with white-wine lees; then lay on the Venice glass (ground fine and mixed with salt of tartar and litharge) and bake it as directed.

A Green.—Take copper dust two parts; yellow glass two parts; melt them twice. *Or,*

Two parts of copper filings, one of lead ashes, and one of white glass; melt them to a cake.

A good Yellow.—Take of antimony, red lead, and sand, an equal quantity; melt to a cake.

A fine Blue Glass to paint with.—Take lead ashes one pound, clear sand two pounds, salt two pounds, white calcined tartar one pound, flint glass half a pound, zaffre half a pound; melt them together, and quench them in water; then melt them again, and repeat this several times.

Zaffre, finely ground by itself, makes a good blue to paint on white-glazed earthen-ware.

A Brown.—One part of manganese, one of lead, and one of white glass.

A Liver Colour.—Take twelve parts of litharge, eight of salt, six of pebble or flint, and one of manganese.

A Sea Green.—Take five pounds of lead-ashes, one pound of tin-ashes, three pounds of flint, three quarters of a pound of salt, half a pound of tartar, and half a pound of copper-dust.

To lay Gold, Silver, or Copper on Earthen-Ware, so as to resemble either of these Metals.

MAKE any utensil of fine potter's earth; form and shape it thin, neat, and silver fashion; then bake it, and when baked, glaze it: but, before you bake it again, if you wish to silver, gild, or copper it, take a regulus of antimony and melt any of the above metals with it, and beat it to a powder; grind it with water, very fine, and glaze it therewith. Then

Then bake it, and when done, the whole utensil will look like silver; for when it comes into the fire, the antimony evaporates, and leaves the silver, &c. behind. But if you would silver or gild only for the sake of ornament, and keep the articles so ornamented from the wet, then lay on the gold or silver leaves with brandy, and afterwards polish and finish them in the best manner after the common method.

PART V.

DIRECTIONS FOR CASTING, OR TAKING OFF IMPRESSIONS; WITH RECEIPTS FOR CASTING

IN

SILVER, COPPER, BRASS, TIN, STEEL, AND OTHER METALS;

LIKEWISE IN

WAX, PLASTER OF PARIS, WOOD, HORN, &c.—WITH THE MANAGEMENT OF THE RESPECTIVE MOULDS.

CASTING, among sculptors, implies the taking of casts and impressions of figures, busts, medals, leaves, &c. The method of taking of casts of figures and busts is most generally by the use of plaster of Paris, i. e. alabaster calcined by a gentle heat. The advantage of using this substance, preferably to others, is, that notwithstanding a slight calcination reduces it to a pulverine state, it becomes again a tenacious and cohering body, by being moistened with water, and afterwards suffered to dry; by which means either a concave or a convex figure may be given by a proper mould or model to it when wet, and retained by the hardness it acquires when

when dry, and from these qualities it is fitted for the double purpose of making both casts, and moulds for forming those casts. The particular manner of making casts depends on the form of the subject to be taken. Where there are no projecting parts, it is very simple and easy; as likewise where there are such as form only a right or any greater angle with the principal surface of the body; but where parts project in lesser angles, or form a curve inclined towards the principal surface of the body, the work is more difficult. The first step to be taken is the forming the mould. In order to this, if the original or model be a bass relief, or any other piece of a flat form, having its surface first well greased, it must be placed on a proper table, and surrounded by a frame, the sides of which must be at such a distance from it as will allow a proper thickness for the sides of the mould. As much plaster as will be sufficient to cover and rise to such a thickness as may give sufficient strength to the mould, as also to fill the hollow betwixt the frame and the model, must be moistened with water, till it be just of that consistence as will allow it to be poured upon the model. This must be done as soon as possible, or the plaster would concrete or set, so as to become more troublesome in the working, or unfit to be used. The whole must then be suffered to remain in this condition, till the plaster has attained its hardness; and then the frame being taken away, the preparatory cast or mould, thus formed, may be taken off from the subject entire. Where the model or original subject is of a round or erect form a different method must be pursued; and the mould must be divided into several pieces: or if the subject consists of detached and projecting parts, it is frequently most expedient to cast such parts separately, and aftewards join them together. The art of properly dividing the moulds, in order to make them separate from the model, requires more dexterity and skill than any other thing in the art of casting, and does not admit of rules for the most advantageous conduct of it in every case. Where the subject

is of a round or spheroidal form, it is best to divide the mould into three parts, which will then easily come off from the model: and the same will hold good of a cylinder or any regular curved figure. The mould being thus formed, and dry, and the parts put together, it must be first greased, and placed in such a position that the hollow may lie upwards, and then filled with plaster mixed with water, and when the cast is perfectly set and dry, it must be taken out of the mould, and repaired where it is necessary, which finishes the operation. This is all that is required with respect to subjects where the surfaces have the regularity above-mentioned: but where they form curves, which intersect each other, the conduct of the operation must be varied with respect to the manner of taking the cast of the mould from off the subject or model; and where there are long projecting parts, such as legs or arms, they should be wrought in separate casts. The operator may easily judge, from the original subjects, what parts will come off together, and what require to be separated: the principle of the whole consists only in this, that where underworkings, as they are called, occur, that is, wherever a straight line, drawn from the basis or insertion of any projection would be cut or crossed by any part of such projection, such part cannot be taken off without a division; which must be made either in the place where the projection would cross the straight line; or, as that is frequently difficult, the whole projection must be separated from the main body, and divided also lengthwise into two parts; and where there are no projections from the principal surfaces, but the body is so formed as to render the surface a composition of such curves, that a straight line being drawn parallel to the surface of one part would be cut by the outline, in one or more places, of another part, a division of the whole should be made, so as to reduce the parts of it into regular curves, which must then be treated as such. In larger masses, where there would otherwise be a great thickness of the plaster, a core or body may be put within the mould, in order to pro-

duce

duce a hollow in the cast; which both saves the expence of the plaster, and renders the cast lighter. This core may be of wood, where the forming a hollow of a straight figure, or a conical one, with the basis outward, will answer the end: but if the cavity require to be round, or of any curve figure, the core cannot be then drawn while entire; and consequently should be of such matter as may be taken out piece-meal. In this case, the core is best formed of clay; which must be worked upon wires to give it a tenacity, and suspended in the hollow of the mould by cross wires lying over the mouth; and when the plaster is sufficiently set to bear handling, the clay must be picked out by a proper instrument. Where it is desired to render the plaster harder, the water with which it is tempered should be mixed with parchment size properly prepared, which will make it very firm and tenacious. In the same manner, figures, busts, &c. may be cast of lead, or any other metal, in the moulds of plaster; only the expence of plaster, and the tediousness of its becoming sufficiently dry, when in a very large mass, to bear the heat of melted metal, render the use of clay, compounded with some other proper materials, preferable, where large subjects are in question. The clay, in this case, should be washed over till it be perfectly free from gravel or stones; and then mixed with a third or more of fine sand, to prevent it cracking; or, instead of sand, coal ashes, sifted fine, may be used. Whether plaster or clay be employed for the casting in metal, it is extremely necessary to have the mould perfectly dry: otherwise the moisture, being rarefied, will make an explosion that will blow the metal out of the mould, and endanger the operator, or at least crack the mould in such a manner as to frustrate the operation. Where the parts of a mould are larger, or project much, and consequently require a greater tenacity of the matter they are formed of to keep them together, flocks of cloth, prepared like those designed for paper hangings, or fine cotton, plucked or cut till it is very short, should be mixed with

the ashes or sand before they are added to the clay to make the composition for the mould. The proportion should be according to the degree of cohesion required; but a small quantity will answer the end, if the other ingredient of the composition be good, and the parts of the mould properly linked together, by means of the wires above directed. There is a method of taking casts in metals from small animals, and the parts of vegetables, which may be practised for some purposes with advantage: particularly for the decorating grottos or rock work, where nature is imitated. The proper kinds of animals are lizards, snakes, frogs, birds, or insects, the casts of which, if properly coloured, will be exact representations of the originals.

Casts of medals, or such small pieces as are of a similar form, may be made in plaster by the method directed for bass relievos. Indeed there is nothing more required than to form a mould, by laying them on a proper board, and having surrounded them by a rim, made by the piece of a card or any other pasteboard, to fill the rim with soft tempered plaster of Paris; which mould, when dry, will serve for several casts. It is nevertheless a better method to form the mould of melted sulphur, which will produce a sharper impression in the cast, and be more durable than those made of plaster. The casts are likewise frequently made of sulphur, which being melted must be treated exactly in the same manner as the plaster. For taking casts from medals, Dr. Lewis recommends a mixture of flowers of brimstone and red lead: equal parts of these are to be put over the fire in a ladle, till they soften to the consistence of pap: then they are kindled with a piece of paper, and stirred for some time. The vessel being afterwards covered close, and continued on the fire, the mixture grows fluid in a few minutes. It is then to be poured on the metal, previously oiled and wiped clean. The casts are very neat; their colour sometimes a pretty deep black, sometimes a dark grey: they are very durable; and when soiled, may be washed clean in spirits of wine. Dr. Lettsom recommends tin-

tin-foil for taking off casts from medals. The thinnest kind is to be used. It should be laid over the subject from which the impression is to be taken, and then rubbed with a brush, the point of a skewer, or a pin, till it has perfectly received the impression. The tin-foil should now be pared close to the edge of the medal, till it is brought to the same circumference: the medal must then be reversed, and the tin-foil will drop off into a chip box or mould, placed ready to receive it. Thus the concave side of the foil will be uppermost, and upon this plaster of Paris, prepared in the usual manner, may be poured. When dry, the whole is to be taken out, and the tin-foil sticking on the plaster will give a perfect representation of the medal, almost equal in beauty to silver. If the box, or mould, is a little larger than the medal, the plaster running round the tin-foil will give the appearance of a white frame or circular border: whence the new-made medal will appear more neat and beautiful. Casts may be made likewise with iron, prepared in the following manner: "Take any iron bar, and having heated it red-hot, hold it over a vessel containing water, and touch it very slightly with a roll of sulphur, which will immediately dissolve it, and make it fall in drops into the water. As much iron as may be wanted being thus dissolved, pour the water out of the vessel, and pick out the drops, formed by the melted iron, from those of the sulphur, which contain little or no iron, and will be distinguishable from the other by their colour and weight." The iron will, by this means, be rendered so fusible, that it will run with less heat than is required to melt lead, and may be employed for making casts of medals, and many other such purposes, with great convenience and advantage. Impressions of medals having the same effect as casts, may be made also of isinglass glue, as will be seen hereafter.

Impressions of medals may be likewise taken in putty, but it should be the true kind, made of calx of tin, and drying oil. These may be formed in the moulds, previously

ously taken in plaster or sulphur; or moulds may be made in its own substance, in the manner directed for those of the plaster. These impressions will be very sharp and hard; but the greatest disadvantage that attends them, is their drying very slowly, and being liable in the mean time to be damaged. Impressions of prints, or other engravings, may be taken from copper-plates, by cleansing them thoroughly, and pouring plaster upon them; but the effect in this way is not strong enough for the eye, and therefore the following method is preferable, where such impressions on plaster are desired. Take vermillion, or any other coloured pigment, finely powdered, and rub it over the plate: then pass a folded piece of paper, or the flat part of the hand, over the plate to take off the colour from the lights or parts where there is no engraving; the proceeding must then be the same as where no colour is used. This last method is also applicable to the making of impressions of copper-plates on paper with dry colours; for the plate being prepared as here directed, and laid on the paper properly moistened, and either passed under the rolling press, or any other way strongly forced down on the paper, an impression of the engraving will be obtained. Impressions may be likewise taken from copper-plates, either on plaster or paper, by means of the smoke of a candle or lamp; if, instead of rubbing them with any colour, the plate be held over the candle or lamp till the whole surface become black, and then wiped off by the flat of the hand, or paper. These methods are not, however, of great use in the case of copper-plates, except where impressions may be desired on occasions in which printing ink cannot be procured: but as they may be applied likewise to the taking impressions from snuff-boxes, or other engraved subjects, by which means designs may be instantly borrowed by artists or curious persons, they may in such instances be very useful. The expedient of taking impressions by the smoke of a candle or lamp may be employed also for botanical purposes in the case of leaves, as a perfect

a perfect and durable representation of not only the general figure, but the contexture and disposition of the larger fibres may be extemporaneously obtained at any time. The same may be nevertheless done in a more perfect manner, by the use of linseed oil, either alone or mixed with a small proportion of colour, where the oil can be conveniently procured: but the other method is valuable on account of its being practicable at almost all seasons, and in all places, within the time that the leaves will keep fresh and plump. In taking these impressions it is proper to bruise the leaves, so as to take off the projections of the large ribs, which might prevent the other parts from plying to the paper. Leaves, as also the petals, or flower leaves, of plants, may themselves be preserved on paper, with their original appearance, for a considerable length of time, by the following means.—Take a piece of paper, and rub it over with isinglass glue, treated as above directed, for taking impressions from medals; and then lay the leaves in a proper position on the paper. The glue laid on the paper being set, brush over the leaves with more of the same; and that being dry likewise, the operation will be finished, and the leaves so secured from the air and moisture, that they will retain their figure and colour much longer than by any other treatment. Butterflies, or other small animals, of a flat figure, may also be preserved in the same manner.

To prepare Clay for making all Sorts of Moulds to cast Gold, Silver, and other Metals in.

TAKE clay, as much as you will; put it into an earthen pot that is glazed, and cover and lute it very close; then put it into a potter's furnace, and let it stand as long as other earthen ware. After it is burned, and cold, grind the clay upon a colour-stone very fine; sift it through a fine

fine hair sieve into clear water, and after it is settled, pour off the water, and grind the clay once more upon the stone, as fine as possible; then wash it again in fair water as before, and set it in the sun, or in a warm place, to dry.

After this is very dry take three pounds of it; sal-ammoniac two pounds, tartar two pounds, vitriol one pound; mix them together, and put this mixture into one or two pots; pour upon it about seven quarts of clean water, and boil this composition for some time; then take this water, whilst it is warm, and mix burnt clay therewith to such a consistence that you may form it into balls; lay these in a warm place to dry, and when dry, put them into an earthen pot as before, and give them another baking among the earthen ware, and when cold, grind them fine, and that powder will be fit for use.

The clay being thus prepared, take sal-ammoniac, and put it into a glass with water, that holds about two quarts; put so much of the sal-ammoniac to the water as will dissolve it over a gentle warmth, and let it stand one or two hours closed up; then take your powder of clay, and temper it with this water to such a consistence as to form it into balls, and make what moulds you please thereof. When you cast your metal, you must make your mould red hot; and be nimble in pouring out the metal.

To make Moulds of Clay to cast Brass or other Metals in.

Take good clear clay, such as the pewterers use; take also cloth shaving, or fine short plucked cotton, and fine clear sand, and if the sand is not fine enough, grind it on a colour-stone; mix this with the clay to such a consistence as is fit to make or form your moulds thereof. Your clay must not be made soft with water, but with strong beer; and when you cast, let your mould be red hot.

If

If you would have a fine and sharp cast, sift over your clay some fine washed ashes, before you make the impression.

A particular Sort of Mould, in which one may cast very fine and sharp.

Take horse muscle-shells; or, for want of them, oyster-shells; let them be calcined in a potter's furnace; then pulverize and temper them with urine: of this make your moulds, and you will cast very fine and sharp.

To impress Basso Relievo, or Medals, in Imitation of Ivory.

Take of prepared clay one pound, fine plaster of Paris eight ounces, white starch eight ounces; mix these together, and beat up the mixture with the white of six or eight eggs; put to it three ounces of clear gum arabic; stir it well together to a paste, and put so much of the dry mixture to it as will knead it like dough; then press it into a mould with the palm of your hand, and let it dry in the sun, observing to lay the paste side on a smooth board, and it will be clear and hard, like ivory. You may impress all manner of medals and curiosities, and make them of what colour you please.

To impress Medals and other things in Basso Relievo, on Paper.

Take the shavings of superfine white paper, and steep them in fair water for six or eight days; then put them into a clean earthen pot, with water, and boil them for two or three hours: this done, take them out of the pot, with as little moisture as possible, and stamp them in a stone

mortar

mortar very small and fine; then put them into a clean linen bag, and hang that in a vessel with clean water, changing the water once or twice a week: when you have occasion to use it, take as much as you want out of the bag, squeezing the water from it, and put it on the mould, pressing it down gently with a spunge, which will soak up the water, and make the impression more perfect; this being done, set the mould to dry in the sun, or in a warm room, and when dry, the impression will come off as fair and sharp as if cast in plaster of Paris.

To cast Vegetables in Moulds peculiarly prepared for Silver.

TAKE fine and clear clay that is dry, and pound it in a mortar; then take a copper or iron pan; put in your clay, and give it a brisk fire, and after you have heated it thoroughly, take it off and let it cool; then take one part of this clay, and one part of plume alum; grind them together, and cast the mixture in little tents, which put into a fire to neal; beat it very fine; and when you would form your plant, take one part of this powder, and one part of plume alum; grind them together, and add as much of the clay powder as the mixt matter contains, and mix and grind them all together. Then take some potter's clay, to make a coffin round your plant; spread it in what manner you think proper; and after the coffin is dry, anoint the inside thereof, as also the plant, with good brandy; dust the before prepared clay, and the plant, gently through a fine cambric; and when you have covered it all over as thick as it will bear, strike the raised coffin a little with your hand or hammer, and the dust will settle closer to the plant, and make the silver come out the sharper.

After the powder is well settled, and your coffin closed, cover it fine with dead charcoal, and then lay some live

ones

ones over them; let the fire gradually descend to the coffin, and heat it by degrees to a strong glue; then let it cool of itself with the fire; take, afterwards, fine clay, fine sand, and some wool shearings; mix these together; beat and knead them well into one another; then temper the mixture with glue, and fill your coffin with it all over the plant, leaving an opening at the stalk for the inlet; then put it again into the fire and make it red hot, and with a pair of bellows, first closed, draw out the ashes from the inlet, and it will be ready for casting.

Then take oil of tartar, which is made of pounded salt of tartar, and scrape a little sal-ammoniac into it, to give it the substance of a thin paste, which is a good flux for silver; fling some of this upon your silver, when in fusion, and it will cast fine and sharp.

After it is cast, anoint the silver plant with oil of tartar; lay it on live coals; neal it, and then boil it in tartar, to which add a little salt, and this will give it a fine bright pearl-colour.

Powders for Moulds to cast all Sorts of things in Gold, in Silver, or in other Metals.

TAKE powdered plaster of Paris; or instead, take alabaster in powder, and sift it through cambric, or a very fine hair sieve, and put it into an iron pan, over a clear coal fire; stir it about until it begins to boil and bubble up like water; keep it stirring; recruit your fire, and continue this until you find it so thick as not to be able to draw it along with your stick; then pour it into a bowl, and let it cool.

Take also brick-dust finely powdered and sifted.

The miners find sometimes a matter in the iron mines which they call *liver-ore*; take this, and wash it from the coarser sand, and when dry, put it into an earthen pot; cover

cover it, set it to neal thoroughly, and when cold, pound and sift it. When it is right burnt, it will be of a copper colour; put all these different powders into several boxes, and preserve them from dust and soil, for proper use.

Another Method to cast Vegetables and Insects.

FOUR parts of the above plaster of Paris, two parts of brick-dust, and two parts of liver-ore; mix them well together, and sift them through a fine hair sieve; when you are ready to form your moulds, pour clean water to them, and stir them well together to the thickness of a thin paste: you must be pretty nimble with this work, else it will harden under your hands, and be of no use.

To prepare the Mould.

TAKE the plant you design to cast, and spread the leaves and stalks so as not to touch one another; then make a coffin, either of lead or clay, and put your plant in it so as not to touch the sides; at the bottom you may lay a piece of paper to keep the stuff from sticking to the board, but let your stuff be neither too thick nor too thin, for if it is of a right consistence it will force itself close to the plants and come out sharp; let the stalks be carefully kept up for the inlet; and when you pour this stuff upon your plants, do it gently, and separate those leaves which might lie close to one another with a needle, pouring all the while, to make the mould the stronger. After this is hardened, put it in a dry place, and keep it until you have some more ready to cast; but you must secure it from frost.

If you would cast insects, or any small animal, or reptile, put them, in what position you will, upon a little board, brown paper, or paste-board, which first must be anointed with

with oil, to make the plaster-stuff come off the easier; about your insect make a little coffin, and if you can raise the insect so as to be freed from the board or paper, it will be the better, which you may do by tying it with two or three hairs, and fastening them at the top of the coffin, by which it will hang in the middle; when this is ready, pour, as before directed, your plaster gently upon it, and after the mould is a little dry, it will be fit for use.

To cast Figures, or Medals, in Sulphur.

MELT (in a glazed pipkin) half a pound of sulphur over a gentle fire; with this mix half a pound of fine vermillion; when you have cleared the top, take it off the fire, and stir it well together, and it will dissolve like oil; then cast it into the mould, after being first anointed with oil; let it cool, and take it out; but in case your figure should change to a yellowish colour, you need only wipe it over with aqua-fortis, and it will look like the finest coral.

How to form and cast all Sorts of small Birds, Frogs, Fish, &c.

TAKE an earthen, iron, or tin ring, which is high and wide enough to hold the animal you design to cast, and set it upon a clean board, or paste-board; then lay the animal upon it, and cast the mixture of fine plaster pretty thick over it; the rest of the vacancy you may fill up with a coarser plaster, even to the brim: when this is done, and pretty well dried, turn your ring, and putting a little short stick close to the body of the animal, cast a crust on that side, to cover that part which before lay close to the board, and when dry, burn it, and go about the casting as directed: after you have burned it thoroughly, you must draw the ashes

ashes out at the hole which is made by the little stick, and this you may use for your inlet.

How to cast small Shot.

MELT your lead in a ladle; then pour it gently, in a continual stream, into a pan or pail of water, on the surface whereof swims oil of a finger thick; thus you will have good round small shot.

To prepare Wax for Moulds.

TAKE one pound of white resin that is not greasy, and two pounds of wax; melt the wax; strain it through a cloth into a glazed pan, and stir it about till it is cool.

To cast Medals and other things in Basso Relievo.

LAY your medal on a clean piece of paper, or a clean board; inclose it with a wall of clay or wax; then pour the plaster of Paris half an inch thick upon it; when it is dry, take off the mould, and anoint it with clear sallad oil, two or three times, both within and without. If you will cast plaster of Paris, lay the mould first for a quarter of an hour in clear water; then cast your plaster as thick as you please.

You must observe that whenever you make a mould of plaster, let it be for basso relievo, or figures, you must always anoint it with oil, two or three times, which will not only preserve them from the damage they otherwise would sustain from the water, but make the cast pieces come out clear.

Medals

Medals and Figures in Basso Relievo, like Jasper.

To do this you must have a hand-spout, at the end of which fix a tin or iron plate, full of round holes, some larger than others. In this spout put a paste, made of fine chalk of several colours; then force them out in small shreds of mixed colours in one piece; cut them with a fine edged knife in thin round slices, and put one into your mould, pressing it down gently; then pour the plaster of Paris upon it, and, when dry, lay it first over with fish glue, and after that varnish it, and it will be of singular beauty.

The colours you may first dilute with gum-water, before you mix the chalk with them.

To cast Figures in Imitation of Ivory.

Take isinglass and strong brandy; make it into a paste, with the powder of very fine ground egg-shells. You may give it what colour you please; but cast it warm into your mould, having oiled it all over; leave the figure in the mould till cold; then set them in the air to dry, and you will have them resemble ivory.

Another.

Take a sufficient quantity of egg-shells; put them into an earthen vessel; lute it well, and let them be put in a potter's furnace, and they will burn to a white calx; if, after the first burning they are not white enough, burn them a second time; then, with parchment-glue, mix it into a mass fit to be cast in moulds, wherein let them dry: if you will have your figures of different colours, you must colour

colour your glue; for red, with brazil; for green, with verdigrise, &c.

Another Mixture to cast Figures in Basso Relievo.

TAKE flower of chalk, finely ground; mix it with clear glue well together; pour it into your mould; press it with the palm of your hand, and it will come out very fine: you may do this in what colour you please.

To cast with Marble Colours in Plaster.

TAKE several colours, as vermillion, Dutch pink, yellow ochre, smalt, &c.: temper them with water, and mix every one apart with plaster: then take what colours you please, and, first sprinkling your mould, which is best of sulphur, with one or more of them, with a little pencil or feather; then pour a colour different from what you sprinkled into the mould, and after it is hardened, give it a gloss with wax or varnish, as pleases you best.

A Sand in which one may cast things to the greatest nicety, whether Flat, or in Basso Relievo.

TAKE fuller's earth; put it in a reverberatory furnace till it is red hot; then take sal-ammoniac, about one pound; dissolve it in two quarts of water; with this water moisten the burnt earth, and, when cool, put it into the furnace in a red-hot pan: after it has glown there, take it out again; when the heat is a little over, sprinkle it with the above water again, till it is quenched; then give it another fire, and repeat this five or six times; the more, the better it will receive the metal: grind it to a very fine powder;

powder; put it into the frame, which may be either of brass, iron, or wood, but first moisten it a little with the aforesaid water; then make your impression near the ingot, and having dried it before the fire, while it is hot, cast your metal; the mould or impression will be better the second than the first time using it, but every time you use it, make it first red-hot.

To make Horn soft.

TAKE one pound of wood-ashes, two pounds of quick-lime, one quart of water; let it boil together to one third; then dip a feather into it, and if, in drawing it out, the plume comes off, it is boiled enough; if not, let it boil longer; when it is settled, filter it through a cloth; then put in shavings, or filings, of horn; let them soak therein three days: and, anointing your hands first with oil, work the horn shavings into a mass, and print, mould, or form it in what shape you please.

To cast Horn into Moulds.

TAKE horn shavings as many as you will, and lay them in a new earthen pot; take two parts of wood-ashes, and the third part of lime; pour clear lye upon it, so as to cover it all over; boil it well; stir it with an iron ladle, till it has the consistence of a paste: if you will have it of a red colour, then take red-lead, or vermillion, as much as you think proper, and temper it with the paste; then cast it into a mould, and let it dry: you may smooth it with a knife, and it will be of one solid piece; you may in this manner bring horn to what colour you will have it.

To cast Wood in Moulds, as fine as Ivory, of a fragrant Smell, and in several Colours.

TAKE fine saw-dust of lime-tree wood; put it into a clean pan; tie it close up with paper, and let it dry by a gentle heat; then beat it in a stone mortar to a very fine powder; sift it through cambric.

Then take one pound of fine parchment glue; the finest gum-tragacanth and gum-arabic, of each four ounces; let them boil in clear pump-water, and filter through a clean rag; stir into it of the aforesaid powder of wood; till it becomes of the substance of a thick paste, and set it in a glazed pan in hot sand; stir it well together, and let the rest of the moisture evaporate till it be fit for casting. Then pour, or mix, your colours with the paste, and put in oil of cloves, of roses, or the like, to give it a scent; you may mix it, if you will, with a little beaten amber: for a red colour, use brazil ink; and for other colours, such as will be directed under the article for book-binders. Your mould will be better of pewter, or brass, than of plaster of Paris; anoint it over with oil of almonds, and put your paste into it; let it stand three or four days to dry and harden; then take off your mould, and it will be as hard as ivory; you may cut, turn, carve, and plane it like other wood; it will be of a sweet scent; you may, if your mould will allow it, use several colours in one piece, leaving only in some part the natural colour of the wood, in order to convince the beholder what it is. It is a fine and curious experiment.

MIXTURES

MIXTURES FOR CASTING MIRRORS, AND FOR CASTING OTHER THINGS.

RECEIPTS for preparing these mixtures are prescribed by several authors, after different ways; wherefore we shall set down only a few, that for the generality are best approved: and first,

For reflecting Mirrors.

TAKE three pounds of the best refined pewter, and one pound of refined copper. First melt the copper, and then add the pewter to it: when both are in fusion, pour it out, and, when cold, beat it to powder: then take twelve ounces of red tartar, a little calcined tartar, three ounces of nitre, one ounce and a half of alum, and four ounces of arsenic: mix and stir these together, and, after it has done evaporating, pour out the metal into your mould; let it cool; and when polished you will have a fine mirror.

Another.

THE metals for reflecting telescopes are often composed of 32 parts of copper, and 15 of grain tin, with the addition of two parts of arsenic, to render the composition more white and compact.

Another.

MR. EDWARDS found that 32 parts of copper, 15 of tin, one of brass, one of silver, and one of arsenic, made a most excellent metal, which is the hardest, whitest, and possesses

the most reflective powers he ever met with. It must be observed, that reflectors made with these last proportions are difficult to cast, as well as to grind and polish; and on that account the inexperienced are recommended to employ the second composition: the copper and tin are to be melted in separate crucibles, and in their fused state they are to be mixed, and the arsenic is to be added. When the scoria is removed from the fluid mass it is to be poured as quickly as possible into the moulds: when the metal is solid and cool it is to be annealed, then ground and polished.

How to take Impressions with Isingglass, from Copper-plates.

TAKE fine white isingglass, as much as you please; cut it fine, and put it into a glass, or cup; pour on it so much brandy as will just cover the isingglass; close it well, and let it soak all night; then pour some clear water to it, and let it soak another night; pour some clear water to it, and boil it on a gentle coal fire, until a drop of it put on a knife is like a clear jelly; strain it through a cloth, and put it into a cool place, where it will jelly, and be ready for use.

When you are about casting a picture, cut so much of the jelly as you think you have occasion to cover the copper-plate with; dissolve it in a clean pipkin, or such like utensil, over a slow coal fire, and mix any of the colours, to be hereafter mentioned, amongst it; mean while your copper-plate must be cleaned; then wipe the plate carefully with clean hands, as the copper-plate printers do; and when this is done, pour your dissolved isingglass over it, but not too hot, spreading it with a pencil very even every where until your copper-plate is covered: set it then in a moderate warm place to dry; and when you perceive it thoroughly dry, then, with the help of a thin blade of a knife, you may

lift

lift it up from the plate; if you find the matter has been made too thin, add more isingglass to it; but if too thick, add a little more water, and boil it again.

Of the Colours fit to be mixed with Isingglass, for Impressions of Plates.

1. For red; mix with it some of the liquid in which you have boiled scarlet rags.

2. For blue; take litmus, dissolved in fair water, and mix it.

3. For green; take distilled verdigrise; grind it as fine as possible, and mix it.

4. For yellow; steep saffron in fair water, and mix it.

5. A gold colour is made with the above red and saffron-yellow.

6. Gold, silver, or copper, separately well ground, as for painting, may be severally mixed with the materials, and poured quickly over the plate. If you first rub printers black in the graving, the gold and silver will look the better.

To cast Plaster of Paris on Copper-plates.

First rub the colour, either red, brown, or black, into the graving, and wipe the plate clean; then mix as much plaster as you think you shall have occasion for, with fresh water, to the consistence of a thin paste, and having put a border round the plate, of four pieces of reglet *, pour the plaster upon it, and move it so as that it may run even all over the plate; let it stand for an hour, or longer, according to the dimensions of the plate, and when you find it dry, and turned hard, take off the reglets, and then the plaster,

* A *reglet* is a ledge of wood used by printers.

 and

and you will have a fine impression of the copper graving. You must observe not to mix more at a time than you have occasion for, else it will grow hard before you can use it.

To take a cast in Plaster of Paris from a person's face.

The person must lie on his back, and his hair must be tied back. Into each nostril must be put a conical piece of paper, open at both ends, to allow of breathing. The face is to be lightly oiled over, and the plaster being properly prepared, is to be poured over the face, taking care that the eyes are shut, till it is covered to the thickness of a quarter of an inch. The plaster will, in a few minutes, be hard enough to be removed. In this a mould is to be formed, from which a second cast is to be taken, that will furnish casts exactly like the original.

PART VI.

MECHANICAL ARTS;

WITH

RECEIPTS FOR SMITHS, CUTLERS, PEWTERERS, BRAZIERS, BOOK-BINDERS, JOINERS, TURNERS, &c.

SMITHING.

SMITHING, or Smithery, is an art by which an irregular lump of iron is wrought into any intended shape. The tools or implements chiefly used by the Smith are as follows:

The *forge*, which is built up from the floor with brick, about 2½ feet high, with hollow arches underneath to set several things out of the way. The back of the forge is carried upright to the top of the ceiling, and enclosed over the fire-place with a hovel, which ends in a chimney to carry away the smoke. In the back of the forge against the fire-place is fixed a thick iron plate, and a taper pipe in it about five inches long, called a tewel, in which the pipe of the bellows is placed, and which preserves the said pipe and back of the forge from burning. At the ear of the upper bellows-board is fastened a rope, chain, &c. which reaches up

up to the rocker, and is fastened there to the farther end of the handle. The handle is fastened across a rock-staff, which moves between two cheeks upon the centre-pins, in two sockets; so that by drawing down the handle, the moving board of the bellows rises, and by a considerable weight set on the top of its upper board, sinks down again, and by this agitation performs the office of a pair of bellows. To the forge is fixed a long hollow trough for water.

The *anvil* is usually made with a beak-iron, for the sake of hollow work: its face must be very flat and smooth, without flaws; and so hard, that a file will not touch it. It is set on a steady wooden block, about two feet high from the ground.

Smiths make use of two sorts of tongs: the one straight-nosed tongs, used when the work is short, and for plate-iron. The other crooked-nosed, made use of in forging small bars, or other thick work, which may be held within the chaps.

Hammers used in smithery are, 1. the hand-hammer of such a weight, that it may be weilded with one hand at the anvil. 2. The up-hand sledge, used by under workmen, when the work is not of the largest kind, yet requires help to batter it, or draw it out: they use this with both hands before them, and seldom lift their hammer higher than their head. 3. The about-sledge, which is the largest hammer of all, and used by the under workmen, who hold the farther end of the handle in both hands, and swinging the sledge above their heads, they at arms-length let fall as heavy a blow as they can work. 4. The rivetting hammer is the smallest of all, and rarely used at the forge.

The *vice* is set up very firmly, and parallel with the work-bench: the chaps must be cut and well tempered: the screw pin is cut with a square strong worm, and the spring must be made of good strong steel, well tempered. The wider the two ends of the spring stand asunder, the wider it throws the chaps of the vice open. The foot must be straight to bear heavy blows the better

The

The *hand-vice* is used for small work; it is held in the left-hand, so that each part of work may be turned to the file in succession.

The use and construction of pliers, pincers, &c. are well known. The *drill-bow* is used in making such holes as cannot conveniently be made with a punch. It must be made of good well tempered steel. The drill-plate is only a piece of flat-iron fixed upon a flat board, with holes punched a little way into it, to set the blunt end of the shank of the drill in, when a hole is made through any piece of work.

In forging, the smith uses his slice to clap the coals together, to keep the heat in the body of the fire; for the same purpose the outside of the fire is continually damped with the sprinkling of water. The great art in smithing is to give the iron the proper and necessary degree of heat, of which there are several, as the blood-red heat; the white heat; and the welding heat. The first is used in smoothing iron that already has its proper shape: the white heat is necessary when the iron has not its proper shape; and the welding heat, when it is required to join two pieces of iron together. This will serve for the general principles of Smithing.

CUTLERY.

THOUGH cutlery in the general sense comprises all those articles denominated edge-tools, it is more particularly confined to the manufacture of knives, forks, scissars, pen-knives, razors, and swords. Damascus was anciently famed for its razors, sabres, and swords. The latter are said to possess all the advantages of flexibility, elasticity, and hardness. All those articles of cutlery which do not require a fine

 polish,

polish, and are of low price, are made from blistered steel. Those articles which require the edge to possess great tenacity, at the same time that superior hardness is not required, are made from sheer-steel. The finer kinds of cutlery are made from steel which has been in a state of fusion, and which is termed cast-steel, no other kinds being susceptible of a fine polish. Table knives are mostly made of sheer-steel, the tang and shoulder, or bolster, being of iron, the blade part being attached by giving them a welding heat. The knives after forging are hardened by heating them red hot, and plunging them into water; they are afterwards heated over the fire till they become blue, and then ground. The handles of table-knives are made of ivory, horn, bone, stag-horn, and wood, into which the blades are cemented with resin and pulverized brick. Forks are made almost altogether, by the aid of the stamp and appropriate dies. The prongs only are hardened and tempered. Razors are made of cast steel, the edge of a razor requiring the combined advantages of great hardness and tenacity. After the razor blade is forged, it is hardened by gradually heating it to bright red heat, and plunging it into cold water. It is tempered by heating it afterwards till a brightened part appears of a straw colour. It would be more equally effected by sand, or what is still better, in hot oil, or fusible mixture, consisting of eight parts of bismuth, five of lead, and three of tin. A thermometer being placed in the liquid at the time the razors are immersed for the purpose of indicating the proper temperature, which is about 500 of Fahrenheit. After the razor has been ground into its proper shape, it is finished by glazing and polishing. The glazor is formed of wood, faced with an alloy of lead and tin; after its face is turned to the proper form and size, it is filled with notches, which are filled up with emery and tallow. This instrument gives to the razor a smooth and uniform surface, and consequently a fine edge. The polisher consists of a piece of circular wood running upon an axis, like that of the stone or the

the glazor. It is coated with leather, having from time to time its surface covered with crocus martis. The handles of high priced razors are made of ivory and tortoise shell, but in general they are of polished horn, which are preferred on account of their cheapness and durability. The horn is cut into pieces, and placed between two corresponding dies, having a recess of the shape of the handle. By this process the horn admits of considerable extension; if the horn is not previously black, the handles are dyed black by means of a bath of logwood and green vitriol. The clear horn handles are sometimes stained so as to imitate the tortoise-shell: this is effected by laying upon the handle a composition of three parts of potash, one of minium, ten of quick-lime, and as much water as will make the whole into a pulpy mass. Those parts of the handle requiring darker shades, are covered thicker than the other. After this substance is laid upon the handles, they are placed before the fire the time requisite for giving the proper effect.

The manufacture of pen-knives is divided into three departments; the first is the forging of the blades, the spring, and the iron scales; the second, the grinding and polishing of the blades; and the third, the handling, which consists in fitting up all the parts, and finishing the knife. The blades are made of the best cast steel, and hardened and tempered to about the same degree with that of razors. In grinding they are made a little more concave on one side than the other; in other respects they are treated in a similar way to razors. The handles are covered with horn, ivory, and sometimes wood; but the most durable are those of stag-horn. The most general fault in pen-knives is that of being too soft. The temper ought to be not higher than a straw colour, as it seldom happens that a pen-knife is so hard as to snap on the edge.

The beauty and elegance of polished steel is not displayed to more advantage than in the manufacture of the finer kinds of scissars. The steel employed for the more valuable

valuable scissars should be cast steel of the choicest qualities; it must possess hardness and uniformity of texture for the sake of assuming a fine polish, great tenacity when hot for the purpose of forming the bow or ring of the scissar, which requires to be extended from a solid piece, having a hole previously punched through it. It ought also to be very tenacious when cold, to allow that delicacy of form observed in those scissars termed ladies' scissars. After the scissars are forged as near to the same size as the eye of the workmen can ascertain, they are paired. The bows and some other parts are filed to their intended form, the blades are also roughly ground, and the two sides properly adjusted to each other after being bound together with wire and hardened up to the bows. They are afterwards heated till they become of a purple colour, which indicates their proper temper. Almost all the remaining part of the work is performed at the grinding mill, with the stone, the lap, the polisher, and the brush. It is used to polish those parts which have been filed, and which the lap and the polisher cannot touch. Previously to screwing the scissars together for the last time, they are rubbed over with the powder of quick-lime, and afterwards wiped clean with a skin of soft sheep leather. The quick-lime absorbs the moisture from the surface, to which the rusting of steel is justly attributed. Scissars are frequently beautifully ornamented by blueing and gilding, and also with studs of gold or polished steel. The very large scissars are partly of iron and partly of steel, the shanks and bows being of the former. These, as well as those all of steel which are not hardened all over, cannot be polished: an inferior sort of lustre, however, is given to them by means of a burnish of hardened polished steel, which is very easily distinguished from the real polish by the irregularity of the surface. For a more full account of this business, see Dr. Rees's Cyclopedia, a work that cannot fail to last as long as true science is cultivated.

To

To harden Sword-blades.

SWORD-BLADES are to be made tough, so as not to snap or break in pushing against any thing capable of resistance; they must also be of a keen edge; for which purpose they must all along the middle be hardened with oil and butter, to make them tough, and the edges with such things as shall be prescribed hereafter, for hardening edged instruments. This work requires not a little care in the practice.

How to imitate the Damascan Blades.

THIS may be done to such perfection that they cannot be distinguished from the real Damascan blades. First polish your blade in the best manner, and finish it by rubbing with flower of chalk; then take chalk mixed with water, and rub it with your fingers well together on your hand; with this touch the polished blade, and make spots at pleasure, and set them to dry before the sun, or a fire; then take water in which tartar has been dissolved, and wet your blade all over therewith, and those places that are left clear from chalk will change to a black colour; a little after, wash all off with clear water, and the places where the chalk has been will be bright.

How the Damascan Blades are hardened.

THE *Turks* take fresh goat's blood, and after they have made their blades red-hot, they quench them therein; this they repeat nine times running, which makes their blades so hard as to cut iron.

To harden Steel and Iron, which will resist and cut common Iron.

TAKE shoe-leather, and burn it to a powder; salt, which is dissolved, and glass-gall powdered, of each an equal quantity; then take what you desire to harden and wet it therewith, or lay it in urine, and taking it out, strew it over with this powder, or else stratify it therewith in an earthen pan; give it for five hours a slow fire to cement, and make it afterwards red-hot for an hour together.

Several other Temperings of Steel and Iron.

1. IRON quenched in distilled vinegar, or in distilled urine, becomes of a good temper.

2. Vinegar, in which sal-ammoniac has been dissolved, gives it a good temper.

3. So does the water, in which urine, salt, and salt-petre have been dissolved.

4. Mix together an equal quantity of saltpetre and sal-ammoniac, and put the mixture into a phial with a long neck; then set it in a damp place, or in horse-dung, where it will turn to an oily water; this liquor will make iron works of an incomparable temper and hardness, if quenched therein red hot.

5. A lye made of quick-lime and salt of soda, or of pot-ash, filtered through a linen cloth, gives a very good hardness to iron, if quenched therein.

6. The dung of an animal, mixed with water and calcined soap to a thin paste, gives such a good temper, as to make it cut untempered iron.

7. Or take *Spanish* radishes, grate them on a grater, and express their juice; this gives a good temper to iron or steel quenched therein.

8. Take

8. Take the juice of nettles, fresh urine, ox-gall, salt and strong vinegar, equal quantities of each; this mixture gives an incomparable temper.

9. Red-hot iron or steel, wiped over with goose grease, and then quenched in sour beer, takes also a good temper.

To harden Armour.

Of the following take an equal quantity: common salt, orpiment, burned goat's horn, and sal-ammoniac; powder and mix them together; then anoint the armour with black soap all over, strew this powder upon them, and wind a wet rag about them, and lay them in a fierce charcoal fire, till they are red-hot; then quench them in urine. If you repeat it, it will be the better.

To temper Steel or Iron, so as to make excellent Knives.

Take clean steel, quench it in distilled rain, or warm water, and the juice of *Spanish* radishes; the knives made of such steel will cut iron.

To bring Gravers and other Tools to a softer Temper.

Take a little pan with live charcoal, and put a couple of old files, or any other small bars of iron over it; then lay your gravers upon them, and when you see them change to a yellowish colour, it is a sign that they are softer; after this colour they change to a reddish, which shews them still softer: and if you let them turn to a blue, then they are quite soft and unfit for use: after this manner you may soften any steel that is too hard.

General

General Rules to be observed in tempering of Iron or Steel.

We know by experience, that the tempering of iron may be performed and executed several ways; for every mechanical branch requires a particular method of hardening. The tools that are used for wood, require a different temper or hardness from those used in cutting of stone or iron, and therefore are prepared, according to the several methods treated of before: an artist ought to acquaint himself with the powers of the different ingredients and liquors that are here prescribed, and improve upon such as seem most promising. He is to observe the degrees of heat, which he is to give, and the length of time he is to keep the metal in the liquor for quenching; for if the iron be made so excessively hot that it is not capable of receiving a greater degree of heat, it cannot well be quenched, and it will become cankered; but if it appears of a saffron or reddish colour, it is called gold, and is fit to be quenched, for hardening: however, in this, as well as most other things, practice is the best instructor.

Method of hammering Iron without Fire, and making it Red Hot.

Take a round iron, about an inch thick; at one end thereof fix a round iron knob; then begin gently to hammer it under the knob, turning it quickly round; and by following your strokes harder and harder, the iron will heat of itself, and begin to be red hot; because the knob keeps the heat, on each of the motions, from passing off.

To soften Iron or Steel that is brittle.

1. Anoint it with tallow all over; neal it in a gentle charcoal fire, and let it cool of itself.

2. Or take a little clay, lime, and cow's dung; cover your iron with it, and neal it in a charcoal fire: then let it cool of itself.

3. Or, make iron or steel red hot, and strew upon it good hellebore, and it will become so soft that you may bend it which way you please: this is very useful for those who cut in iron or steel.

4. Take lead, put it into a crucible, or iron ladle, and melt and pour it into oil; this repeat seven times running. If you afterwards quench iron or steel in this oil, it will be very soft; and after you have shaped or worked it in what manner you please, you may harden it again by quenching it in the juice of onions.

5. Take lime, brick-dust, and *Venice* soap; with this anoint your steel, and neal it; then let it cool of itself.

6. Wind about the steel some thin slices of bacon, and over that put clay; let it neal for an hour, and the steel will be very soft.

7. Take quick-lime and pulverized soap, of one as much as the other; mix together, and temper it with ox's blood; with this anoint the steel; then lay a covering of clay over it, and let it neal and cool of itself.

8. Take the juice or water of common beans, quench your iron or steel in it, and it will be as soft as lead.

TO

TO ETCH UPON SWORD OR KNIFE BLADES.

To prepare a Composition for Etching.

TAKE mercury and aqua-fortis, put them together into a glass, till the mercury is consumed, and it is fit for use.

To make the Ground.

TAKE three ounces of red lead, one ounce of white lead, half an ounce of chalk, all finely pounded; grind these together with varnish, and anoint your iron; let it dry in the sun, or before a slow fire, and with a pointed steel, or needle, draw or write on it what you please; and then etch it with the above prepared water.

To etch 100 *or more Knife-blades at once.*

GRIND red lead with linseed oil or varnish; with this wipe your blades all over, and let them dry well, and harden; then write, or draw, with a pointed bodkin, whatever you will; put them at some distance from each other, into a glass or well glazed pot or pan; dissolve some vitriol in hot water, pour it over the blades, and lute the glass or pot; set it over a gentle coal-fire; let it boil for some time, and then let it cool; then take your blades out; scrape the red lead off, and you will find the etching to your satisfaction.

To make blue Letters on Sword-blades.

TAKE the blade; hold it over a charcoal fire till it is blue; then, with oil colours, write what letters you will upon the blade, and let them dry; when dry, take good strong vinegar; make it warm, and pour it all over the blade; this will take off the blue colour; wet your oil colour with fresh water, and it will come off easily, and the letters drawn therewith remain blue.

To harden Fishing Hooks.

AFTER you have (of good wire) made your small fishing hooks, you must not put them into the fire to harden, but lay them upon a red hot iron plate; and when they are red, fling them into water; take them out again, and when dry, put them again on the hot iron plate, and when they appear of an ash-colour, fling them again into cold water; this will make them tough, otherwise they will be brittle.

To gild upon Iron or Steel.

TAKE common salt, saltpetre and alum, an equal quantity of each; dissolve them in as little warm water as possible; then filter them through whited brown paper; add leaf gold, or rather thin beaten gold, to it, and set it on hot sand, to make it almost boiling hot; keep it in that heat for twenty-four hours, and if the water evaporate, you may supply it with more; but at last let it all evaporate, and it will turn to a yellow salt; this pulverize; put it into a glass, and cover it with strong brandy, or spirit of wine, two inches high above the powder: then stop your glass close,

close, put it into a gentle warmth, and the brandy, or spirit, will extract all the gold, and be of a beautiful colour. With this water you may, with a new pen or pencil, write or draw what you please upon a sword-blade, knife, or any other thing made of iron or steel, and it will be gilded to a high colour.

OF LEAD AND PEWTER.

To make Pewter hard.

Take one pound of common pewter, and let it melt in an iron pan; add to it some salad oil, let it evaporate well, and stir it continually, keeping the flame from it; add some fine wheaten flour, and stir it well about; then take all the burnt matter off the top, and to each pound add three or four ounces of plate brass, filed small, and mixed with oil, and a few ounces of pulverized bismuth, or regulus of antimony; when all is melted and incorporated, you will not only have a pewter that is harder and whiter, but also different in its sound from common pewter.

Another Method to make Pewter as White as Silver.

Take clean copper one pound, and let it flux; add to it of the best English pewter one pound, and continue the flux; to this add two pounds of the regulus of antimony, and let it still flux for half an hour; then cast it into an ingot. Beat this in a mortar to a fine powder, and fling thereof as much into melted tin as you think requisite: you will find it of a fine silver colour; it will be hard and give a fine

a fine sound: to make it flux the better, you may add a little bismuth.

To make Tin which shall have the Weight, Hardness, Sound, and Colour of Silver.

Take fine crude crystal antimony; beat it fine, and wash it in water until it becomes sleek, and let it dry again.

Then take well dried nitre and tartar, of each an equal quantity; beat them fine, and put them together into an earthen pan, on which lay some live charcoal, and the nitre and tartar will soon begin to fulminate; cover the pan with a lid; let the matter burn out and cool, and you will find a yellow salt: this salt beat to powder, before it is quite cold, and put thereof, into a crucible, one pound, and of the washed antimony two pounds. Mix them well together, and let it flux in a wind furnace for three quarters of an hour: then fling a little lighted small-coal into them, and let them consume, and stir them well together with a stick. Presently after, take the crucible out of the fire; beat it a little down to the bottom, and let it cool of itself; then break the crucible, and you will find a silver-coloured regulus of three quarters of a pound weight.

Then take two pounds of old copper; cut it fine; neal it, and quench it, ten times running, in very strong lye made of the above tartar and rain water. Take it while wet, and put it into a crucible, with one pound of fine beaten arsenic, *stratum super stratum*. When all is in the crucible, pour as much linseed oil on it as will cover the matter; then cover and lute your crucible; put it into a new pan; fill it all round with sand, and set it three hours in a circular fire: after it is cold, open it, and you will find the copper spungy and of several colours. Of this take two pounds, and plate-brass two pounds; melt these together; add, by

 degrees,

degrees, the copper, and give it a quick fusion in a wind furnace: then add two pounds of English pewter, half a pound of bismuth, and two pounds of the above regulus; let it flux well: then pour it out, and you will have a fine silver mixture. Beat this into a fine powder; mix it, with linseed oil, to a paste, and with a spatula add it to melted pewter; stir it well together, and you will have a fine tin, which will resemble silver exactly.

A particular Method to make Tin resemble Silver.

Melt four ounces of fine plate-brass, add to it four ounces of fine clean tin, and when in fusion, add four ounces of bismuth, and four ounces of regulus of antimony; let these flux together, and pour it out into an ingot; then beat it to powder; grind it with resin, and a little sal-ammoniac, and with turpentine form it into balls; let them dry in the air; when you would use them, beat them fine, strew the powder thereof upon the melted tin, stir it well together, and continue putting the powdered balls upon the tin, until you perceive it white and hard enough: of this tin you may draw wire, for hilts of swords, or to make buttons; it will always retain its silver colour.

To make Tin Coat-buttons, in Imitation of worked Buttons of Gold and Silk.

Take lamp-black; grind it with oil of spike, and mark the ground-work with a pencil; when dry, draw it all over with a varnish: the best way to imitate worked buttons is, to do them in a fine mould, either stamped or cast; the ground is first filled up with black, blue, red, or any other colour; then the raised part is to be wiped very clean, and when dry, to be drawn over with the varnish, which will

make

make it look much finer than what can be done upon a plain button.

For a brown colour take umber.

For green take distilled verdigrise, mixed with other colours to make it either deeper or lighter.

For grey take white lead, and lamp-black.

All your colours must be ground with oil of spike.

In this manner you may embellish pewter, with a coat of arms, cypher, or ornaments; that is, such pewter things as are not to be scowered.

The Art of making Tin Plates, or Latten.

THERE are only certain sorts of iron which can be reduced into leaves or sheets for that purpose; the best is that which, when heated, is easiest extended, and can be forged with a hammer when cold: the more soft and exceeding flexible, as well as the more brittle, are to be rejected. These leaves are drawn from bars of iron about an inch square, which, being made a little flat, they cut into thin pieces, and fold them together into parcels, each parcel containing about forty leaves, which they batter all at once with a hammer of six or seven hundred pounds weight. After this, the principal of the art is to prepare these leaves; for the least dust, or rust, upon their surface, will hinder the tin from uniting with them: this indeed might be taken off by filing, but that being both too tedious and expensive, there is a way to it by steeping them in an acid water for a certain time, and scowering them with sand when taken out; by which method a woman can clean more plates in an hour, than an expeditious workman can file in several days. This water is common water, made sour with rye, which requires very little pains; for, after they have ground the grain grossly, and pounded it, they leave it to ferment in common water for a certain time, and with a little patience they are sure to have

have an eager menstruum: with this they fill troughs or tuns, into which they put piles of iron plates; and to make it grow eager the better, and have more activity, they keep these vessels in vaults or stoves, which have a little air, and in which they keep lighted charcoal; the workmen go into these vaults once or twice a day to turn the plates, to take out such as are sufficiently cleansed, and put others in their room: and as the liquor is more acid, or the heat of the vault or stove more intense, the plates are sooner cleansed; but it requires at least two days, and sometimes a longer time. This is the method the Germans use for preparing the iron plates for tinning. In France they go another way to work; they dip the iron plates in acid menstruums, as in water wherein alum, common salt, or sal-ammoniac are separately dissolved, and instantly expose them to the air, in order to rust. After two days, during which every plate has been dipt into the menstruum twice or thrice, they are scowered. These menstruums, though weak in themselves, produce the effect as well as the stronger which are much dearer; among the latter, vinegar is the most effectual, especially if you dissolve a little sal-ammoniac therein, about a pound or two in a puncheon; by this means the iron rusts sooner than with any other salt, but it must be used very moderately, and the leaves be left to steep in clean water, to dissolve any particles of it that may stick to its surface, which may otherwise make it rust after it has been tinned.

In the preparation of the plates it must be observed, 1. In battering them, each parcel should receive the immediate action of the hammer in its turn, otherwise they will not extend equally. 2. Steep them in clay, or fuller's earth, tempered with water, before you heat them, to prevent their soldering with one another.

Whether you make use of the German or French way, in in preparing your plates, it is absolutely necessary, after the plates are sufficiently scaled, to scower them with sand, and

 when

when there remain no more black spots on their surface, to throw them into fair water to prevent their rusting again, and to let them remain, till you are ready to tin them: the manner of doing it is thus; flux the tin in a large iron crucible, of the figure of a broken pyramid with four sides, of which two opposite sides are less than the two others; this crucible you heat from below; the upper rim you must lute quite round in the furnace: the crucible must be deeper than the plates are long, which you dip in downright, so as for the tin to swim over them. The tin being melted in the crucible, you cover it with a layer of a sort of suet, an inch or two thick, through which the plate must pass before it comes into the tin (the use of this is to keep the tin from burning): the common unprepared suet will render the success of the work uncertain: wherefore you prepare it by first frying and then burning it, which not only gives it a blackish colour, but puts it into a condition to give the iron a disposition to be tinned, which it does surprisingly.

The tin itself must have a certain degree of heat, for if it is not hot enough, it will not stick to the iron; if too hot, the coat will be too thin, of several colours, and a dirty yellow cast. To prevent this, you must make an assay with small pieces of the scaled plates, and see when the tin is in proper order. However, you dip the plates into tin that is more or less hot, according to the thickness you would have the coat; some plates you only give one layer, and these you plunge into tin that has a lesser degree of heat than that into which you plunge those which you would have take two layers: when you give these plates the second layer, you put them into tin that has not so great a degree of heat as that into which they were put the first time. Observe, that the tin which is to give the second coat, must be fresh covered with suet, but only with the *common sort*, without preparation: for, melted tin is sufficiently disposed to attach the new tin to be joined.

To

To gild upon Tin, Pewter, or Lead.

TAKE varnish of linseed oil; red lead, white lead, and turpentine; put them together into a clean pipkin, and let them boil; then grind them upon a stone, and when you gild pewter, take a pencil, draw the liquid thin upon what you would gild, and lay your leaf gold upon it; or instead of that, Augsburg metal, and press it with cotton to make it lie close.

Another Method to gild Pewter, or Lead.

TAKE the white of an egg, and beat it clear; with this wipe your tin or pewter, which must be first warmed before a gentle fire, in such places as you design to gild; lay on your leaf gold quick, and press it down with cotton.

The juice of nettles is also fit for that use, and rather better than the clear of white of egg.

A Method to gild with Pewter, or with Tin-foil.

THIS may be done several ways; but the best is to take white lead, ground with nut oil; with this lay your ground on what you design to gild, let it be wood or any thing else; then lay on your gilt tin leaves, press them down with cotton, or a fine rag, and let it dry; when dry, polish it with a horse's tooth or polisher, and it will look as if it had been gilded in fire.

To gild Lead.

TAKE two pounds of yellow ochre, half a pound of red lead, and one ounce of varnish, with which grind your ochre,

 but

but the red lead grind with oil; temper them both together; lay your ground with this upon lead, and when it is almost dry, lay on your gold; let it be thoroughly dry before you polish it.

SOME

EXPERIMENTS RELATING TO COPPER AND BRASS.

To make Brass.

THIS is done by mixing and melting copper and calamine, or zinc, together: calamine is dug in mines about Mendip, &c. in the West of England; it is burnt and calcined in a kiln made red-hot; then it is ground to a powder, and sifted to the fineness of flour, and mixed with ground charcoal, because the calamine is apt to be clammy, to clod, and not apt to incorporate; then they put seven pounds of calamine into a melting pot that holds about a gallon, and about five pounds of copper, uppermost; this is let down with tongs into a wind furnace, one foot deep, wherein it remains eleven hours, (one furnace holds eight pots;) after melting it, it is cast into lumps or plates. Zinc, reduced from its ore of calamine, may be immediately united to copper.

To melt Copper and Brass, and give it a quick fusion.

TAKE nitre, tartar, and salt, and beat them together very fine. When you see that your metal begins to sink with the heat, fling a little of this powder into it, and, when melted,

melted, fling again a little into it, and when you observe it in fusion like water, fling a little again a third time: to twenty-five pounds of metal fling about a walnut size of powder, and your copper or brass will cast easily, and be of a malleable temper.

To make Brass that is brittle, and apt to crack in the Working, malleable.

Take tartar, nitre, and sulphur; pulverize them together; and after you have made your brass red-hot, strew it all over, and let it cool of itself.

A Solder for Brass.

Take one grain and a quarter of silver, three ounces of brass, one ounce of zinc, and melt them together; when melted, fling a good quantity of borax upon them.

To make Copper as White as Silver.

Put your copper into a strong melting-pot, in the midst of a quantity of glass, and set it in a glass furnace to melt; let the copper be covered all over with glass, and the glass will contract the greenness of the copper, and make it look white. If you repeat this several times, your copper will be the whiter.

Take old copper that has been much used, or been long in open air or weather; melt it in a strong crucible before a smith's forge, or in a wind furnace, but take care of the smoke; let it melt a quarter of an hour, or longer, and clear it from the scales that swim at top: then pour it through a whisk, or birch-broom, into a sharp lye, made either

either of quick-lime and vine-branch ashes, or salt of tartar, or such like, and the copper will corn fine and nice; then take it out of the lye, and let it melt again as before; repeat this four times running, in order to purify the copper, and when the copper is well purified, melt it over again; when it is in fusion, fling two ounces of crystalline arsenic in, by little and little; but avoid the smoke, and tie a handkerchief, moistened with milk, about your mouth and nose: after it has evaporated, or rather before it is done, fling into it two ounces of silver; and when that is melted, granulate it again through a whisk, and melt it again for use. It will be fit to make any thing in imitation of silver.

BOOK-BINDING.

Book-binding is the art of sewing together the sheets of a book, and securing them with a back, and strong pasteboard sides, covered with leather, &c. Binding is distinguished from stiching; as in the latter the leaves are only sewed, without bands or backs. There are various kinds of binding; as French-binding, law-binding, marble-binding, binding in parchment, in sheep, in calf, &c.; also half-binding, wherein the leaves are generally left uncut, and only the back covered with leather, the pasteboard sides being covered with marbled or blue paper. Dutch-binding is where the backs are of vellum. The Italians are still contented to bind in a coarse, thick paper, called binding alla rustica, the inconvenience of which is its being liable to wear out without careful use. Without doubt, the art of binding is almost as ancient as the science of composing books; and both the one and the other followed immediately the first invention of letters.

letters. Whatever the matter might be, on which men first wrote, there was a necessity of uniting the several parts together; as well for the making them of one piece, as for the better preserving them; hence the origin of book-binding.

The first operation in book-binding is to fold the sheets according to the form, viz. into two leaves for folio's, four for quarto's, eight for octavo's, &c. which the workmen do with a slip of ivory or box, called a folding-stick; in this they are directed by the catch-words and signatures, which are the letters with the numbers annexed to them, at the bottom of the pages. The leaves thus folded, and laid over each other in the order of the signatures, are beaten on a stone with a heavy hammer to make them solid and smooth, and then pressed. Being thus prepared, they are sewed in a sewing-press, upon pack-threads or cords, which are called bands, at a proper distance from each other, and in a convenient number; which is done by drawing a thread through the middle of each sheet, and giving it a turn round each band, beginning with the first, and proceeding to the last. The common number of bands is six in folio's, and five in quarto's, octavo's, &c.

Book-binders now generally use a saw to make places for the bands, which are sunk into the paper, so that the back of the book, when bound, is smooth, without any appearance of bands. After this the backs are glued, the ends of the bands being opened, and scraped with a knife, for the more convenient fixing of the pasteboards; then the back is turned with a hammer, the book being fixed in a press between boards, called backing-boards, in order to make a groove for admitting the paste-boards. The boards being then applied, holes are made for drawing the bands through, the superfluous ends being cut off, and the parts hammered smooth. Then the book is pressed in order for cutting; which is performed by a particular machine called a plough, to which is fixed a knife. After this the book is put into a press called the cutting-press, betwixt two boards, the one

lying even with the press, for the knife to run upon; the other above it, for the knife to cut against. The book being cut, the paste-boards are squared with a proper pair of iron shears; and it is then ready for sprinkling, gilding, blacking, or marbling the leaves. The colours with which it is sprinkled, are usually vermillion, or sap-green; which is done with a brush made with hog's bristles, holding the brush in one hand, and moving the hair with the other. In the French-binding a book is put in parchment, i. e. a slip of parchment is applied over the back between each band, and the ends pasted on the inside of each paste-board.

In 1799 a patent was granted to Mr. John Williams and Mr. Joseph Williams, Stationers, London, for an improved method of binding all sorts of books. By the specification it appears, that this invention consists of a back, of a semi-circular, semi-oval, or any other curved form, turned a little at the edges, made of iron, steel, copper, brass, tin, or any other metal, ivory, bone, wood, vellum, paper, leather, or any material capable of retaining a firm situation. This back, being put on the book before bound, so as just to cover, but not to press, the edges of the paper, will, when the book is opened, prevent its spreading on either side, and cause it to rise in any part which is opened to nearly a level surface. This firm back, turned at the edges, so as to cause all sorts of books to open freely, is the object of this patent. The method of binding, practised by the inventors, is as follows: they forward the paper in the usual manner; sew on vellum slips, glue, cut, clothe, and board, or half-board; and put on the firm back by fastening it at the sides, through holes, by vellum, or securing it by inclosing it in vellum or ferret wrappers, or other matters, pasted down upon, or drawn through, the boards.

Mr. Ebenezer Palmer, Stationer of London, obtained a patent in 1800 for an improvement in the mode of binding books, particularly account-books of merchants. This consists in the addition of a certain metallic chain, which is made

made or applied in the following manner: first, provide several small bars of metal, about the thickness of a shilling, or more, according to the size and thickness of the book; the length of each bar being from half an inch to several inches long, in proportion to the strength required in the back of the book. At each end of every bar is made a pivot of different lengths, in proportion to the thickness of two links, which they are to receive. Each link is made in an oval form, and contains two holes, proportioned to the sizes of the pivots; and these links are of the same metal as the hinge; each of them being nearly equal in length to the width of two bars. The links are then rivetted on the pivots, each pivot receiving two of them, and thus holding the hinge together, on the principle of a link-chain or hinge. There are further two holes or more of different sizes, as required in each bar of the hinge or chain, by means of which each section of the book is strongly fastened to the same; which hinge, so fastened, operates with the back of the book, when bound, in such a manner, as to occasion the several sections to open so as to bring them on a parallel with each other, and consequently admit the ruled lines being written into, without any inconvenience, close to the back.

Manner of gilding Books on the Edges.

THE book, being put tight into the press, between two boards, is scraped with a knife called a scraper; and after that with another, called a smoother, in order to take out all scratches. Being thus made smooth, they scrape a little yellow ochre upon the book, wet it with a little size water, and rub it off with some clean shavings. The gilding size is made with the white of an egg, mixed with water, and beat well together. The leaves being wetted with the size water, with a brush, the gold is then laid upon it, and afterwards dried before the fire. When dried, it is burnished off with a dog's tooth, set in a handle.

Manner

Manner of blacking the Leaves of a Book.

Blacking the leaves is done with fine antimony, the leaves being wet, and the antimony rubbed upon them until quite dry, when it is burnished like the gold. The head-band is now added, which is an ornament of thread or silk, of two or three colours, placed at each extreme of the book, across the leaves, and woven or twisted, sometimes about a single, and sometimes a double piece of rolled paper, or, what is more lasting, of glued paper thread.

How to cover Books.

For the covers: the skins used undergo several preparations, which we shall explain the method in calf. The calf-skin, being moistened in water, is cut to the size of the book, and the thickness of the edges pared off on a marble stone kept for that purpose. The cover is next smeared over with paste, made of wheat-flour; then stretched over the pasteboard on the out-side, and doubled over the edges within-side. They then cord the book, or bind it firmly between two boards, to make the cover stick the stronger to the paste-boards and the back; on the exact performance of which depends a great part of the truth and neatness of the book. The back is then warmed at the fire to soften the glue, and the leather of the back is rubbed down, with a folding-stick or bodkin, to set and fix it close to the back of the book. It is now set to dry, and when dry, uncorded: the book is then washed over with a little paste and water, the edges and squares blacked with ink, and then sprinkled fine with a brush, by striking it against the hand, or a stick; or with larger spots mixed with vitriol, which is called marbling. Two blank leaves, on each side, are then to be pasted down to the cover, and, when dry, the leaves are burnished in the press, and the cover rolled on the edges. The

The cover is to be glazed twice with the white of an egg; it is then filleted plain, or with gold; and at last polished with a polishing iron, passed hot over the glazed colour. If the book be required to be lettered, they paste a piece of red, or other coloured morocco, on the back, between the first and second band to receive the title in gold letters; and sometimes a second between the next bands underneath, to receive the number of the volume.

To gild the Covers of Books.

In gilding the covers of books the ornaments are made with each its several gilding tool, engraved in relievo; either on the points of puncheons, as those of letters, roses, stars, &c. or around little cylinders of brass, as the lines, embroideries, &c. The puncheons make their impression, by being pressed flat down; and the cylinders, by being rolled along by a handle, to which they are fitted on an iron stay, or axis. To apply the gold, they glaze those parts of the leather whereon the tools are to be applied three or four times with a liquor made of the whites of eggs diluted with water by means of a sponge; and, when nearly dry, they slightly oil them, and then lay on pieces of leaf-gold, and on these apply the tools, with a careful even pressure of the hand, or roll the cylinders, both the one and the other, reasonably hot.

To prepare a Lack Varnish for Book-binders, for French *Bindings.*

When the book is covered, either with calf or sheep-skin, or with parchment, it is struck over with a varnish, and spotted with such colours as are taught under the article of "imitating tortoise-shell on ivory or horn:" some spot the leather before they lay on the varnish; and after they have sprinkled their colour, which they commonly make

make of umber, they lay the varnish over, and polish it with a steel polisher; after which they give it one layer of varnish more, which is the finishing stroke.

French *Leather for binding of Books.*

MAKE choice of such leather as is wrought smooth and fine; strain it on a frame; then, having your colours ready at hand, take first of one sort, in a pencil made of hog's bristles, and, with your finger, knock and sprinkle the colour thereof upon the leather; and when you have done with one, you may take another colour, and proceed with as many colours as you think proper: if you would imitate a tyger's skin, dot your colours upon the leather with a stick that is rough at the end, or with a pencil; and after it is well dried, lay it over with a *Spanish* varnish, which make in the following manner:

Take a pint of highly rectified spirit of wine, of clear gum-sandarac four ounces, clear oil of spike one ounce; pound the sandarac, and put it into the spirit of wine, and then into the oil of spike; let it stand until it is dissolved and settled.

To make White Tables for Memorandum Books, to write upon with a Silver Bodkin or Wire.

TAKE of the finest plaster of Paris; temper it with hartshorn-glue, or any other glue; and having strained the parchment tight and smooth in a frame, wipe it over with the said mixture, on both sides; when dry, scrape it, to make it even; then cover it a second time with the same glue, and when dry, scrape and smooth it as before; this done, take ceruse, and grind it fine with linseed oil that has been boiled; and with a soft hair pencil lay it smooth and even on your parchment, or tables, and set it to dry in a shady place, for five or six days; when dry, wipe them over with a damp sponge, or linen rag, to smooth them, setting them to dry thoroughly until fit for use; then, with a sharp-

edged knife, cut the tables to what size you please to have them, and bind them, fit for the pocket, with a little case for the silver bodkin, or wire, to write with.

To prepare Parchment that resembles Jasper or Marble.

HAVE a trough made in the manner directed under the article of "making marbled paper;" let it be filled with the warm solution of gum tragacanth, and having your colours ready prepared, as will be directed, stir the gum-water with a stick, and put it into a quick circular motion; in the interim, dip your pencil, with colour, in the center thereof, and the colour will disperse and form itself in rounds, as it is carried by the motion of the water; then stir it round in another place, and with a different colour proceed as you did with the first, until your trough is covered with variety of colours. When all is ready, and the water smooth and without motion, lay on your parchment (which before has been laid between damp paper or cloths) and proceed therewith as you do with marbled paper; hang it up to dry, then smooth and glaze it in the manner you do coloured parchment.

A Green Transparent Parchment.

WASH the parchment in cold lye, until it comes clear from it; then squeeze out the liquor as much as possible: if you would have it of a fine green colour, take distilled verdigrise, ground with vinegar, and add a little sap-green to it; temper it neither too thick nor too thin: then soak your parchment in this colour, thoroughly, a whole night; rinse it afterwards in water; strain it immediately on a frame, and set it to dry; then take clear varnish, and lay it on both sides; set it in the sun to dry; after this cut the parchment out of the frame into leaves, as large as you please,

please, and lay them in a book, under a press, to keep them fine and straight; the effect of this parchment is to make a small letter appear as big again; and it is a great preserver of the eyes, especially to those that read much by candle light.

If you would have the parchment of a clear, transparent, and white colour, only wash, strain, and varnish it as above.

For a Transparent Red.

TAKE Brasil-wood, as much as you will; put it into a hot lye, which is clear and not too strong, and it will tincture the lye of a fine red; then pour into it about half an egg-shell full of clear wine; draw the parchment through the colour, and when it is as deep as you would have it, strain it as before.

For a Blue.

TAKE indigo; grind it with vinegar, on a stone, and mix sal-ammoniac among it, to the quantity of a pea; with this wet your parchment, and proceed as has been directed for the green.

For a Violet or Purple Colour.

TEMPER two thirds of the above red, and one-third of the blue, and use it as before directed.

For a Black Colour.

TAKE alum, beat it into a powder, and boil it in rain-water, to a fourth part; then add *Roman* vitriol, with some powdered nut-galls, and boil them together; with this stain

your parchment twice or thrice over, and, when dry, lay the *Spanish* varnish over it.

With these transparent parchments you may make curious bindings. One sort used at *Rome*, is made thus: lay the boards, or paste-boards, over with leaf gold, or leaf-silver, tin-foil, or metal leaves, &c. then binding the parchment over it, it will give it an uncommon lustre and beauty.

The Manner of marbling Paper or Books.

TAKE clear gum tragacanth, and put it into an earthen pan; pour fresh water to it, till it is two hands high over the gum; cover it, and let it soak twenty-four hours; then stir it well together, and add more water to it; keep it often stirring during the day, and it will swell; when you find it well dissolved, pour it through a cullender into another pan, and add to it more water after it has stood a little, and been stirred about, strain it through a clean cloth into another clean pan; keep it well covered, to hinder the dust or any other thing from coming to it: this water, when you go to make use of it in marbling your paper or books, must be neither too thick nor too thin; you may try it with your comb, by drawing the same from one end of the trough to the other; if it swells the water before it, it is a sign that it is too thick, and you must add, in proportion, a little more water.

Your trough must be of the largeness and the shape of your paper, or rather something wider, cut in flag-stone, about four inches deep.

After you have filled your trough with the aforementioned water, and fitted every thing for the work, (before you lay on your colours) take a clean sheet of paper, and draw the surface off, by dipping it flat, which will be a thin sort of film; then have your three colours, namely, indigo mixt with white lead, yellow ochre, and rose pink, ready prepared at hand;

hand; and, for each colour, have two gallipots, in order to temper them as you would have them, in different shades.

All your colours must be ground very fine with brandy.

The blue is easily made deeper or lighter, by adding more or less white lead.

The yellow used for this purpose, is either yellow orpiment, or *Dutch* pink.

For blue, grind indigo and white lead, each by itself, in order to mix the colour either lighter or darker.

For green, take the aforesaid blue and white; add some yellow to it, and temper it darker or lighter, as you would have it.

For red, take either lake, or rose pink, or, rather, ball-lake.

Every one of these colours are to be first ground very fine with brandy, or spirits, and, when you are ready to go to work, add a little ox or fish gall to them; but this must be done with discretion: you may try them, by sprinkling a few drops upon your gum water; if you find the colour fly and spread too much about, it is a sign of too much gall; to remedy which, add more of the same colour, which has no gall, and when you see the colour retract itself again gently, it is right.

When thus you have your colours, and all things in good order, take a pencil, or the end of a feather, and sprinkle on your red colour; then the blue, yellow, green, &c. Begin your red from No. 1, and go along your trough to No. 2; also the blue from No. 3, all along to No. 4:—the yellow and green put here and there in the vacant places; then with a bodkin, or small skewer, draw a sort of a serpentine figure through the colours, beginning from No. 1, to No. 2: when this is done, then take a comb, and draw the same straight along from No. 1, to No. 2. If you would have some turnings, or snail-work on your paper, then, with a bodkin, give the colours what turns you please.

Now

Now you are ready to lay on your paper, which must be moistened the day before, in the same manner as printers do their paper for printing: take a sheet at a time, and lay it gently upon the surface of your colours in the trough, and press it slightly with your finger in such places where you find the paper lies hollow; this done, take hold of one end of the paper, and draw it up at the other end of the trough; hang it up to dry on a cord; when dry, glaze it *, and it is done. You may also embellish your paper with streaks of gold, by applying muscle-shell gold or silver, tempered with gum-water, among the rest of the colours.

To silver Paper, after the Chinese *Manner, without Silver.*

TAKE two scruples of clear glue, made of strips of leather boiled; one scruple of white alum; half a pint of clean water; simmer it over a slow fire; then, your sheets of paper being laid on a smooth table, you dip a pretty large pencil into the glue, and daub it over as even as you can; repeat this two or three times; then sift the powder of talck through a fine sieve, made of lawn, over it, and hang it up to dry, when dry rub off the superfluous talck, which serves again for the same purpose. The talck you are to prepare in the following manner:

Take fine white transparent talck, which comes from Muscovy, and boil it in clear water for four hours; then take it off the fire, and let it stand so for two days: take it out, wash it well, and put it into a linen rag, and beat it to pieces with a mallet: to ten pounds of talck add three pounds of white alum, and grind it together in a little hand-mill; then sift it through a lawn sieve, and, being thus reduced to powder, put it into water, and just boil it up. Then let it sink

* The glazing of this paper is performed with a polished flint, fastened at the bottom of a pole, fixed vertically through a hole in a transverse beam, and rubbed briskly over the paper.

to

to the bottom; pour off the water from it; place the powder in the sun to dry; and it will become a hard substance. Beat this in a mortar to an impalpable powder, and keep it for the use above-mentioned, free from dust.

To make Oil Paper.

TAKE the shreds of parchment; boil them in clear water until it is clammy, and like a strong glue; strain it through a cloth, and with a large pencil strike it over the paper: when dry, varnish it over with a varnish of turpentine.

CARPENTRY.

THE art of employing timber in building is divided into two grand branches; carpentry and joinery. The first includes the larger and rougher kinds of work, and that part which is material to the construction and stability of an edifice; and, generally, all the work in which the timber is valued by the cubical foot. Joinery includes all the interior finishing and ornamental wood-work, and is valued by the superficial foot. We shall here treat of carpentry, and suppose the material arrived in the carpenter's yard, and in the state of whole or squared timber. The operations it undergoes from this period to its final employment in a building, may be classed under two general heads, those which relate to individual pieces, and those which relate to their connection with others. Under the first head are the operations of the pit-saw, by which the whole timber is divided and reduced to the required scantlings or dimensions, relative to

breadth and thickness, without respecting length. Planing, which is giving a smooth face to wood by means of a familiar instrument called a plane, consisting of a chisel fixed in a frame, serving as a handle, by which the workman moves it along over the surface of the timber, shaving off its inequalities: timber thus prepared is said to be wrought. Mouldings of various forms, and performed with particular planes or chissels. Rebating, which consists in diminishing the width of a square, or rectangular piece of timber, for a certain depth on one edge, thus taking off a rectangle of the whole width, and less than the depth of the original piece: this method is particularly used in door-cases, and the frames of casement windows, the rebate forming a kind of ledge for the door or casement to stop against. Grooving or plowing, in which a narrow channel is excavated out of the thickness of the timber: the groove is either square, forming an equal section in the whole depth, or wider at bottom than at top, which is called a dovetail groove. Timber may also be sunk where the piece is formed like a wedge, or rounded; or bevilled in various shapes, which means when the section forms a figure without right angles.

We now come to the second and most important head of the operations, by which timbers are connected together. These are, generally speaking, by mortise and tenon, the first is an excavation, and the second a projection, adapted to it; or by wooden pins or nails, spikes, screws, bolts, straps, and other fastenings of metal, or by glue, though this last is scarcely used except in joinery. The following is a description of the most general and useful methods of joining timbers. First, by simple tenon and mortise, as when joists are framed into trimmers, the most usual method is to make the tenons in the middle of the breadth of the trimmer with a plain shoulder. But when binding-joists are framed into girders, as the binding-joist has to support the bridging-joists, and these the floor, the best method, in order to give strength to the tenon, is to make a rest of a short length under

under the tenon, with a sloping shoulder above, extending in a line from the extremity of the rest to the perpendicular of the square shoulder below at the upper edge of the binding-joist.

When a piece of timber is to be framed between two parallel pieces which are quite immoveable, the true method, in order to make close work, is to make the extremity of the tenon and the bottom of the mortise, at one end, in the arch of a circle, having its centre in one edge of the mortise, and the extremity of the tenon, and the bottom of the mortise at the other end, in a concentric arch from the same centre. As the mortise at this end must be much longer than the breadth of the tenon, there will be a large part of the mortise still open, which may afterwards be filled up. Instead of the bottom of the mortise here being formed in the arch of a circle, it may be cut quite parallel to the edge to the deepest part, as it will not impede the transverse piece in going to its place. This mode of framing is much used in ceiling, joisting for double floors, &c.: the long mortises cut in this manner are called chase-mortises. In forming the tenon and mortise, at the end where the centre is placed, it is not necessary that the mortise and tenon should be so deep as to form an entire quadrant; in this case the bottom may be quite parallel, and only the further edge opposite the centre made circular. When a transverse piece is to be framed between two parallel joists, of which their vertical surfaces are oblique to each other, the upper edge of the transverse piece is turned downwards upon the top of the joists, and marked at the interval or clear; it is then turned upwards into the position in which it is to be placed, the mark at one end is brought into a right line with the vertical surface of the joist, and a line is drawn by the edge of a rule or straight edge placed vertically in the plane of the joist and the transverse piece; this line marks the shoulder of the tenon. The other end is drawn in the same manner. This mode of framing a transverse-joist between two parallel-joists is

is called by workmen tumbling-in-joists. A mortise is cut in the one piece to the breadth of the piece which is to form the perpendicular: the edge of the tenon is cut with a dove-tail notch, so that the piece may be at right angles to the other, and a wedge or key is driven from the other edge of the tenon, which forces it quite close. One inconvenience arising from the dove-tail is, that if the timber of which it is made be not quite dry, the tenon will shrink in proportion to its breadth, and therefore the perpendicular piece will be liable to be drawn to a certain degree. Another method of fixing one piece of timber perpendicular to another, is to mortise the piece forming the base not quite through, enlarging the edges towards the bottom, and making the tenon of the perpendicular piece to fit the upper part of the mortise. Two wedges are then fixed to the bottom of the tenon; where the perpendicular piece is driven, the wedges will be resisted by the bottom, which will split the ends of the tenon, and fill up the mortise to the breadth at the widest place. This mode of fixing one piece at right angles to another is called fox-tail wedging. By this method, so long as the wedges are kept from slipping, the one piece can never be drawn from the other, without breaking the tenon. In order to enlarge the tenon in breadth still more towards its extremity, two other smaller wedges may be put in, of which their ends do not reach quite so far as those of the other two, which, when partly driven, the small wedges will then begin to widen the end of the tenon likewise, and make it fill the mortise completely at the bottom.

The purposes for which wood is employed in modern buildings, and particularly in those of England, are very various. It is used to form the frame-work of the roof, and in laths or boarding, to support the covering of tiles, slates, &c. Long pieces, called bond or chain timber, are laid in the walls to strengthen and bind them together: other flat pieces, called plates, or wall-plates, are placed to receive the ends of the girders, joists, and other timbers, which form the

the framing of the floors, and afford them a level bed. Ties are placed across the building to assist in keeping the opposite walls in their situation; and counteract the lateral pressure of the roof, and diagonal ties at the angles. Lintels are laid over the apertures of doors or windows to support the incumbent walls. The floors are framed with various beams and joists. The rooms are divided with quarter partitions, being a frame-work of small posts and horizontal and diagonal pieces placed at about a foot asunder, and destined to be cased with lath and plaster on the outside. Door and window-frames are also placed in the apertures of the walls. In bad foundations piles are sometimes used; and sometimes planking, and what are called sleepers, pieces of timber laid at short intervals transversely, beneath the foundation wall, and extending about two feet wider: besides all the finishing wood work, such as doors, windows, wainscotting, &c. which belongs to joinery. Carpentry is also employed to construct the centres for arching and vaulting, and frequently in entire bridges, coffer dams, caissons, floodgates, and all the methods of building in water, derive large assistance from this art.

TURNING.

Turning is a very ingenious and useful art, by which a great variety of articles are manufactured, by cutting or fashioning them while they revolve upon an axis or line, which in most cases remains immoveable. Every solid substance in nature may be submitted to this process, and accordingly we have articles turned in the metals, in wood, in pottery, in stone, in ivory, &c. The simplest process of turning

turning is that of the potter, who, in the first stage of forming his ware, sticks a piece of humid clay upon a wheel, or flat table, while it revolves horizontally, and in this state of rotation of the clay he fashions it with the greatest facility into vessels of every description. But in most operations of the art the revolving body is cut or shaved by applying a chissel, or other suitable tool, to its surface, while in motion; a condition that requires firmness in the axis of rotation, and also that the tool itself should be steadily supported. The instrument, or apparatus for these purposes, is called a lathe. Among the great varieties of lathes, it is indispensably required, for circular turning, that the work should be supported by two steady centres, or by parts equivalent to two centres, at a distance from each other in the axis of rotation, and that the tool should be supported by a steady bar, or piece, called the rest.

A great number of turned articles either have, or will admit of a perforation through their axis. All wheel-work, and most of the articles turned in wood, are of this description. Clock and watch-makers accordingly use a very cheap, simple, and portable lathe, called a turn-bench, consisting of a straight bar of iron, about five inches long, with two cross bars or heads, about two inches long, one fixed at the end of the long bar, and the other capable of being shifted by means of a socket and screw. In each of these heads is a centre-pin, terminating in a point at one end, and in a central hole at the other, like the centre-pin, in the poppet-head of any other lathe; the use of which is to afford point-centres when the points are turned towards each other, or hole centres when the contrary is the case; and lastly, there is a small rest with its support, that slides and is adjustable along the bar, as in another lathe. The turn-bench itself is held steady in a vice fixed to a bench or stand. Such pieces as have a hole through the centre, are drawn tightly upon an arbor or mandrel, having a pulley or ferril fixed

upon

upon it, to carry the gut or bow-string, and the mandrel itself is turned between the centres upon its own pointed extremities. There are mandrels fitted up in different ways for holding the work firmly, and if flat, at right angles to the motion. The common lathe of the turners in wood, called the pole-lathe, is the same thing as the watch-makers' turn-bench, but upon a large scale, and a little varied. Instead of the horizontal bar it has two long stout bars of wood, called sheers, forming what is called the bed of the lathe, and its two poppet-heads are upright blocks of wood, mortised in between the sheers, above which they rise and carry the centre screws, and between which they are moveable, and may be wedged firmly at any required distance from each other. The work itself is either put between the centres, or upon a wooden mandrel, and it is made to revolve by a string or band, proceeding from a long springing pole at the ceiling or roof of the shop, round the work, and thence to a treadle or foot-board, which acts by alternate pressure from the foot, while the workman applies the cutting tool with his hands. In these, and all similar lathes, the rotation is made backwards and forwards; and there are some kinds of work in which such a motion is advantageous; but in general, it is much preferable that the work should constantly revolve the same way, as shown in the lathe described under that article, usually known by the name of the foot-lathe. In the regular foot-lathe, work is very seldom turned between the opposite centres, though this method certainly affords great truth and precision. The mandrel is here an essential part of the apparatus, which is always used. It is supported by a centre on the left hand, called the back centre, and by a steel collar in the middle poppet-head; and that the right hand extremity, or nose of the mandrel, terminates in a screw, either convex or concave, the latter of which is preferred in the best lathes. The various description of pieces screwed upon the nose of the mandrel, for holding or carrying work, are called chucks.

pro-

probably because the work is mostly fastened by being driven, jammed, or choked into them. When work is to be turned between centres by the foot-lathe, a centre-chuck, or steel-piece, carrying a projecting point, is screwed on the nose of the mandrel; and as this piece is not harder than blue, and may not always screw home to exactly the same bearing, accurate workmen are in the habit of turning or shaving the point in its place, so that it shall be truly centered. The opposite centre is afforded by the moveable poppet-head, and ought to be truly in the axis; and the mandrel is made to carry the work round by an arm and pin, or by any other ready method of connection. Work, which is not to be turned between centres, is usually fastened to, or fixed in, a block or wooden chuck screwed on the mandrel.

Metallic or other work may be fastened to a wooden chuck by cement, or by glue, or by turning a cell in the wood, and driving the work gently and carefully into it till fixed. The stronger, the firmer, and the better the workmanship of a lathe, the easier it will be to perform work with expedition and truth; but a good workman will make true and excellent work with a very indifferent lathe, by taking care to cut so little at a time that the parts of the engine may never be shaken out of their contact. Metallic lathes, if ever so strong, have an elastic tremor, which makes it difficult to cut brass and bell-metal as firmly and smoothly as in wooden lathes, but the structure of the former admits of greater precision and truth. The velocity of rotation may be extremely swift in wood, slower in brass and bell-metals, still slower in cast iron, and slowest of all in forged iron or steel. The reason for these limits appears to be, that a certain time is requisite for the act of cutting to take place, and that the tool itself, if heated by rotation, will instantly become soft, and cease to cut. Steel and iron require to be kept wetted. For rough work in wood the guage is a good tool, and after that the chissel, with its edge a little convex rather than strait-lined. The graver is commonly

used

used for metal; and for strong rough work, the hook tool, which is of excellent advantage, even in small work, on account of its extreme steadiness. When steel is to be cut extremely clean, a sharp hard tool may be useful, but for the most part in metallic work, even of steel, (if annealed), the hook tool, or graver, need not be harder than purple, or even blue. But to cut steel-work, or chill cast iron cylinders at a high temper, the tool must be very hard, the angle of the edge obtuse, and the motion slow.

Hitherto we have spoken of plain turning, which is indeed the most useful and most universally practised. But many other nice and very curious operations are performed by this art. If the poppet-heads, supporting the mandrel, be made regularly to move from side to side, during the rotation, or the rest be made to approach to, and recede from, the work, any number of times in a turn, the cuts will not be circular but undulating, indented or waved in any curve that may be required. Work of this kind, which is chiefly done in watch-cases, snuff-boxes, and trinkets, is called rose-work. The motion is commonly regulated by certain round plates of brass fixed on the mandrel, called roves, which have their edges waved, and are called roses. Another deviation from regular turning is effected by causing the chuck, which carries the work, to recede crosswise from the centre of the mandrel, back and forward during the rotation. The effect of this is, that the diameters of the work are not all equal to each other. It is practicable to produce a variety cf curves in this way, but in our art the process is confined to turning ovals; and the chuck, by which the work is made thus to slide back and forward, is called an oval chuck. The art of turning is so extensively applicable, that it would require a volume to describe its uses, and the methods of practising it. Every round thing which is made by human hands may be referred to this art, as one of its products.

RECEIPTS

RECEIPTS USEFUL FOR TURNERS, AND OTHERS, WORKING IN WOOD.

To imitate Ebony Wood.

TAKE clean and smooth box, and boil it in oil until it turns black. *Or,*

Take smooth-planed pear-tree wood, strike it over with aqua-fortis, and let it dry in a shady place in the air; then wipe it over with good black writing-ink, and let it also dry in the shade; repeat and wipe the ink over it until the black is to your liking. Then polish it with wax, and a woollen rag.

Another Method.

TAKE what sort of wood you please, box, cedar, mulberry, pear-tree, or the like; steep it for three days in alum-water, in a warm place; or, if it be in the summer, in the sun; then boil it in oil, in which mix some vitriol and sulphur; the longer you boil it the blacker the wood will be; however, you must not let it boil too long, lest it should be scorched.

To Etch Figures upon Wood.

TAKE melted tallow, and, having your table or board of wood ready, form with it flowers, or what else you will, upon it; then, with a coloured water, boiled with vitriol, nitre, and alum, cover the board, over the tallow; let it stand, or repeat it, until the colour pleases you. In this manner you may marble or cloud your wood as pleases you.

To

To Marble upon Wood.

TAKE the whites of eggs, and beat them up until you can write or draw wherewith; then with a pencil, or feather, draw what veins you please upon the wood; after it is dried and hardened for two hours, take quick-lime, and mix it well together with wine; and with a brush, or pencil, paint the wood all over; after it is thoroughly dry, rub it with a scrubbing-brush, so that both the lime and the whites of the eggs may come off together; then rub it with a linen rag, until it is smooth and fine; after which, you may lay over a thin varnish, and you will have a fine marble wood. *Or,*

Grind white-lead, or chalk, together with water, upon a marble very fine; then mix it up with the whites of well-beaten eggs, wherewith paint, or marble, as you think proper; when dry, strike it over with a lye made of lime and urine, and this will give the wood a brown-red colour: upon this colour you may, when dry, marble again with the whites of eggs; and again, when dry, give it another brush with the lye: after you have, with a scrubbing-brush, rubbed off the marbling with whites of eggs, you may strike once more all over with the lye; and your work, when dry and polished, will look very agreeable, and of a fine marbling.

A Gold, Silver, or Copper Colour, on Wood.

TAKE crystal, and beat it in a mortar to powder; then grind it on a marble, with clean water, and put it into a clean new pot; warm it, and add to it a little glue; with this strike, or paint over your wood; when dry, take a piece of gold, silver, or copper, and rub it over therewith, and

you will have the colour of any one of those metals upon the wood, which you may afterwards polish.

To colour Wood of a Walnut-tree Colour.

TAKE the bark of walnut-trees, or the green shells of walnuts; dry them in the sun, and mix as much as you have occasion for with nut oil; boil it up, and rub the wood over with it.

PART

PART VII.

OF

WATER-WORKS, AND FOUNTAINS.

THERE is scarcely any thing in nature, be it ever so beneficial and serviceable, but what may, by some cause or other, exceed its limits, and derogate from its original good into some destructive evil. What is of greater service, both to the animal and vegetable creation, than water, whilst kept within its limits? Again, what in nature is more violent, horrible, and destructive, whenever it either exceeds its bounds, or is obstructed in its natural course? Since the general deluge, we have had many shocking instances, recorded in history, of towns, cities, and countries, swallowed up by inundations; and were it not for making use of artificial contrivances to curb the violence of this element, many more such calamities and disasters would daily happen.—Fields, meadows, and lands would be made useless, and turned into lakes, seas, and other standing waters; from which, now, by the ingenuity and industry of men, they

are securely kept, by dams, sluices, and other contrivances. Arable land, pleasant towns, and flourishing cities, have even been gained by similar means.

It is not intended to enlarge on this subject, it being a task that would require a volume of itself; but only to take notice of a contrivance or two of art and ingenuity, whereby water is made a pleasing scene, as it was formerly exhibited in pleasure-gardens, squares, feasts, and other places of resort. When first the water, by its natural course, is conveyed through pipes from a high torrent, and thence to stream forth through lesser tubes or pipes, that are hidden in various representations of rocks, figures of men and beasts, fish, fowls, &c. such high torrents will afford admirable delight, in cascades, spouts, and in all that art can contrive or invent in water-works. There is no country in the world by nature better situated for an artist to display his genius in water-works than in the parks, gardens, squares, and other places in England, and yet none where it is less encouraged and regarded. This volume might be filled with a description of the most famous and most admired water-works, cascades, and fountains, which excite the admiration of travellers who visit Italy, France, Spain, and other foreign parts; but, for brevity's sake, we shall only notice the surprising curious water-works of the gardens at Versailles in France, which, at an immense expence, are supplied with water from the river Seine near Marly, by a curious engine, that forces water up a high hill into two large basons, and thence, by aqueducts and pipes, to the gardens at Versailles.

Among a vast variety of admirable representations are the grotto, the bason of the crown, the fountain of the pyramid, the cascade of the water-alley, the pavilion-fountain, the water-bower, the theatre, the water-mountain, the bason of Flora, Apollo's bason, the bason of Saturn, the bason of Bacchus, the bason of Latona, the labyrinth, wherein are exhibited the fables of Æsop, and many others, too numer-

ous

ous to be here specified. The principal aim at present is to give the curious reader a mere general hint for contriving water-works in miniature, for his own private amusement.

To force Water by descent, so as to stream through various kinds of Figures in a little Fountain.

Let A B, *plate* VII, *fig.* 1, be a cistern placed above the ceiling of the hall or place where the fountain is to stand, either near the wall of a side-board, or over a table designed for a dessert; C a bason, decorated round the rim with shells, standing on a reservoir D, into which the water empties itself, and is from thence, by a private pipe, let out into the yard; E a palm-tree, which reaches from the bason up to the ceiling, inclosing a pipe, whereby the water is conveyed from the cistern A B to the bason C; F a stopple, to keep the water in, or to let it out of the cistern. The bason C has a close covering, which you may decorate with little hollow figures of silver, copper, brass, or else with porcelain figures, to discharge little streams from their mouth, nostrils, bill, or whatever may have an opening for that purpose. You may, for want of them, make use of figures made of wood, or formed of wax, or other materials, painted over, having small pipes concealed within them: these figures may be made in imitation of men, beasts, birds, fishes, &c. The palm-tree may discharge droppings from the ends of the leaves: it may be represented standing on a little island, with some land animals spouting water. The rest of the surface, painted in imitation of water, may be garnished with swans, ducks, dolphins, &c. Having thus completed your design, you may, by turning the cock, or pulling the stopple out of the cistern, display your art to the admiration of the spectators; or put a stop to it when you please, by closing the vent-hole.

A Foun-

A Fountain of a different Contrivance, for a Dessert after Dinner.

CAUSE a straight round barrel A, *fig.* 2, *plate* VII. to be made of tin, brass, or copper, of what length and dimension you please; fit a round board D to the inside, so as it may with ease slip up and down; coat the rim round with leather, to keep the water above board; underneath it fasten, to the middle, a pliable steel spiral spring G, by which the board may be forced from the bottom to the top of the barrel. Fasten the other end to the bottom B, and fix to the board D, close to the centre of the spring, a cord H, which reaching down below the middle of the bottom of the barrel through a little hole, you may thereby pull down the board D, in order to empty the bason when full. The conveyance of the water into the bason C, and into the figures which are to send it forth in little streams, must be thus performed: the bason, which may be of what bigness you please, yet proportionable to the place where the entertainment is to be, must have a flat or a convex cover, on which you place such figures as have been taken notice of in the foregoing direction; at the bottom of the bason let there be a round opening E, close to the middle of the top of the barrel; at one end of the cover must be a hole F, which you may open and close at pleasure: this machine must be fixed, so that the top of the barrel may be level with the table. Somebody pulls down the board by the string H, while another fills the barrel through the hole F: this done, cork the hole, then the spring will force the water by means of the board into the bason, and from thence into the fountain figures; the bason being full, open the whole F, and pulling down the board with the spring, all the water will empty itself into the barrel again; then closing the hole F, and letting loose the spring, the fountain will play as before.

A is

PLATE VII.

A is the barrel; B the bottom of the barrel; C the bason; D the round board; E the opening by which the water enters in, and empties itself out of the bason into the barrel; F the hole in the cover of the bason; G the spiral spring; H the string fastened to the board D, by which it is pulled down.

To force Water into little Streams, by Compression.

CAUSE a barrel, *plate* VII, *fig*. 3, to be made of copper, close at bottom, of what height you please; fit a plug of pretty hard and heavy wood so as to slip up and down with ease, the sides of this plug to be covered round with leather; bore several holes through, towards the middle, over which fasten hollow figures of men, or of fish, birds, &c. having small pipes that may spin little streams from their mouth, bill, &c. Conveyances may also be made to the figures round the bottom of the barrel or cylinder. Fill the barrel with water, and put the wooden plug on the surface; the pressure will cause the water to spin from the little figures, and from the figures at the bottom of the barrel.

A the barrel, B the plug, C the figure of Neptune on the plug; D D the figures at the bottom of the barrel.

A Pump by Mr. Conyers.

THE structure of this pump is as follows: A A, *fig*. 1, *plate* VIII. is the body of a square tapering pump, made of oak, elm, or deal-planks, with a valve at bottom, *a*; B the bucket, in whose middle is a valve *b*; C the iron to raise the bucket; D the wood at the bottom of the bucket, containing the valve; E the handle for raising the bucket, to be managed by fewer hands than ordinary pumps are:

(it

(it may be altered so as to employ a horse, in mill-work, more advantageously than the strength of men); F, a square taper box forming the bottom, with holes in the sides, but open at bottom, in whose narrower part is enclosed the narrow end of the body of the pump; G an additional bucket, of larger dimensions, to be placed on the iron work of the pump about H, whenever it be needful to lengthen the taper of the pump, to raise the water more forcibly to a greater height; I, a flat spout to cast out the water, of the same breadth with the side of the pump; K the iron or wooden work set off, or bent back, if needful, and placed behind the pump, for the easier and fuller motion of the pump-handle which moves in it. This pump is eight feet and a half long, and one foot eight inches broad at top, and about eight inches broad at bottom, where it is inserted in the box. It throws eight gallons at a stroke; and twenty-one strokes being made in one minute, there are one hundred and sixty-nine gallons delivered in that time; whereby it is easy to compute what quantity is thrown out in an hour. This kind of pump may be made of a tree, bored through with a taper bore; and a basket may be used for the bottom of the pump, instead of the present box with holes in it.

A curious Engine, by which Water is thrown to a great Distance, by Compression: the Tube turning every Way, is fitted to direct a jet of Water to places where Fire is to be extinguished.

What is peculiar in this engine, is, that the jet of the water is continual, and not interrupted, even when the sucker of the pump ceases to force. This engine is a square chest of copper A, *fig.* 2, pierced above with many holes B B, holding within it the body of a pump E F M, whose sucker D E is raised and lowered by two levers

levers C O, C O, with each of them two arms, so as to be wrought by the hands of a man; and each lever is pierced in the middle by a mortise, wherein an iron nail, which passeth through the handle of the sucker, turns when the sucker is raised or lowered. Near the body of the pump is a copper vessel I H K, which communicates with it by the tube G, with another tube K N L, which in N may be turned every way. To make this engine play, water is poured upon the chest, which enters in at the holes in the cover. This water is drawn into the body of the pump at the hole F. The sucker is first raised, and, when the same is depressed, the valve of the hole F shuts, and forces the water through the hole M, into the tube G, whose valve H being raised, the water enters into the pot, and filling the bottom, it runs through the hole K, into the tube K N L, and the hole of the tube G is shut by the valve H; the air in the vessel has no vent, and it happens, that when you continue to make the water enter into the vessel by the tube G, (which is much thicker than the aperture, at the extremity L, at which it is discharged,) it must needs be that the surplus of the water that enters into the vessel, and exceeds that which at the same time issues through the small end of the jet, compresses the air in the vessel, by which means, whilst the sucker is raised again, (that new water may enter into the body of the pump,) the compressed air in the vessel drives the surplus of water by its spring, in the mean time that a new depression of the sucker makes more water to enter, and causes also a new compression of air; and thus the stream of the water that issues by the jet, is continual.

OF

OF GROTTOS AND SHELL-WORK.

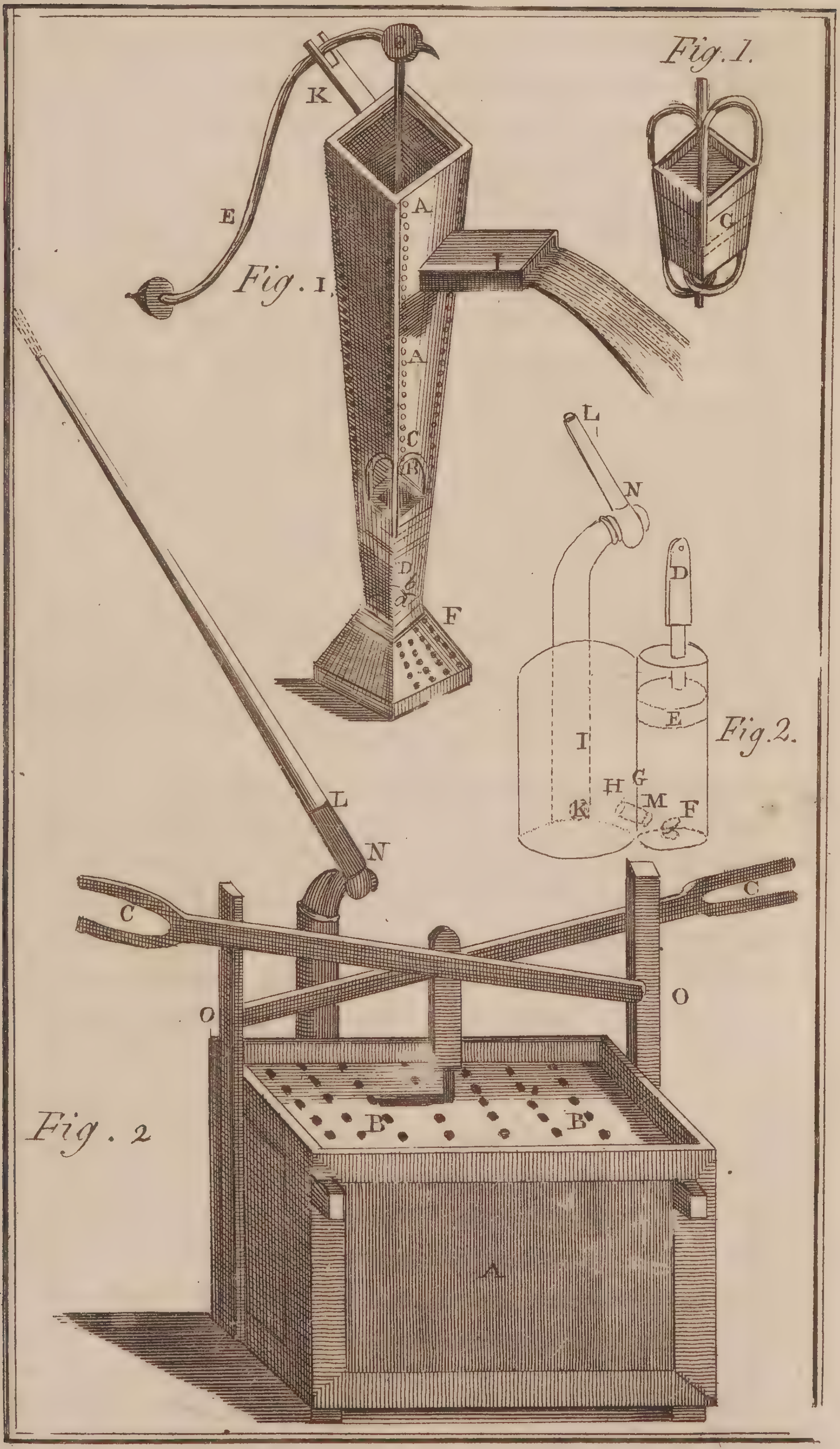
CONCERNING grottos in general, it must be remarked that few of these are to be met with in this kingdom, which has the greatest advantages by nature, and the best opportunities for collecting the most rare and beautiful shells, of all parts in the known world. We shall therefore lay before the curious a plan for grottos, that may with ease and small expence be imitated in every private pleasure-garden, to the great delight and satisfaction of the owner, and all that may be admitted to the sight of them.

Let us suppose there is a canal, bason, or fish-pond, or a river flowing along the side, or in your garden. The water from one or the other may easily be conveyed by pipes, to what distance you please, and consequently to that place where you intend to build your grotto; there you sink the ground to the depth you would have it, and make the advance to it by steps, or a sloping walk from the garden. Now, as this place is to imitate and represent a natural grotto, cave, or cavern, frequently met with among cliffs, rocks, hills, and mountains, and to make them appear in the same manner and shape, rustic, confused, and without order, we must endeavour, in copying after them, to come as near the resemblance of nature as possible; for the nearer we come up to her, the more valuable, perfect, and artful the work will be looked upon and esteemed.

Having copied the natural rustic order, by natural rock-stones, or by glass, or furnace-cinders, and divided the apartments into their proper dimensions, convey the water from the main pipe to small ones; proceeding thence, in several branches, to proper places in the rock-work, unite them to hollow figures, or to the small pipes concealed in them, so as upon turning a certain cock, water may stream out. Thus, the grand and rustic work being compleated,

and

PLATE VIII



and the figures for the water-works fixt to their proper stations, we now, by artful contrivances, ornament, embellish, and dress it up in the greatest beauty and imagination that art can produce. For this purpose, we beforehand make choice of a quantity of various sea-shells, pieces of looking glass, crystal, coral, amber, marble, agate, or whatever may add grandeur and beauty to the place. The pavement is commonly laid of black and white marble, or mosaic of various coloured pebbles. The figures, whence issue forth streams of water, are generally cast of lead. The entrance is ornamented with the largest shells: the most beautiful are reserved for the inside. They are fixed to the main grotto by a cement, which is prepared in the following manner:

Take of quick-lime six ounces, and a pint of wine; mix them, and let it stand five or six days, stirring it every day; after which, pour off the clear, and mix it with the powder of calcined flint-stones, which you pound in a mortar. You may give it what colour you please, by mixing some earthen colours among it.

The cement for the first and coarser work is made of two parts of white resin, four parts of bees-wax, melted together; to which add finely powdered marble, or free-stone, two or three parts, and one part of flour of brimstone: incorporate all together over a gentle fire, and afterwards knead it with your hands in warm water: with this cement you join the stones, cinders, or ore, first heating them a little before the fire.

The chief concern in building a grotto, is to be very careful in the choice of some grand design, for the structure and embellishments. *Plate* IX. *fig.* 1. will, at first view, shew the effect of the front, which ought to be bold and grand. Here the figures should be in their full proportion, whatever they may be in the inside of the grotto. What light soever is let in, must be from the entrance; and, if there be more than one apartment, it is thrown in at an opening at top, by a sky-light. This instruction may be of service to gentlemen

who

who are experienced in the art of building, as they may improve upon what is here advanced, to the best of their skill and knowledge.

Here follows a grotto in miniature, not only proper to adorn the toilet, but likewise to serve instead of a dressing-box.

A A, *fig.* 2, is a nest of drawers, which has several divisions for different uses. B the middle large drawer; C C two deep side-drawers; D, a middle shallow drawer, for pens. E, an under drawer to contain writing-paper. F a looking-glass at the further end of the grotto G, which is garnished with the most beautiful shells, moss, crystals, coral, &c. H an ink-stand with a stopple of china-image-work: I a sand-box, of the same. K a box for wafers, of the same. L L two beautiful pyramids of shells. M a drawer; the front may be embellished with curious shells. The drawer B may be framed with shell-work; and the front be a picture enamelled, or painted in water-colours, with a glass before it. N two front corner-supporters, carved and gilded, of the figures of turtles, or else natural turtle-shells. The two side pillars may include looking-glass, framed with small shells.

This explanation will be sufficient for the cabinet-maker to improve his fancy and ingenuity in making useful and ornamental grottos, for the amusement of ladies who delight in elegant works.

We might in this part of our work have given an account of clepsydræ, instruments of great antiquity, and which were formerly used to mark out the divisions of time before sun-dials were invented. They depended on the continual dropping of water through a small aperture, similar in principle to an instrument represented in Plate III. fig. 6. Here the middle part is a tube filled with sand, which runs out into the box beneath, and as the sand descends the stone resting upon it descends also, and (by being passed over a pulley, and connected with an index) draws up the index which points to the hours.

PART

PLATE IX.

PART VIII.

DIALLING.

DIAL, or sun-dial, is a plane, upon which lines are described in such a manner, that the shadow of a wire, or of the upper edge of a plate stile, erected perpendicularly on the plane of the dial, may shew the true time of the day. The edge of the plate by which the time of the day is found, is called the stile of the dial, which must be parallel to the earth's axis; and the line on which the said plate is erected, is called the substile. The angle included between the substile and stile, is called the elevation, or height of the stile

Those dials whose planes are parallel to the plane of the horizon, are called horizontal dials; and those dials whose planes are perpendicular to the plane of the horizon, are called vertical or erect dials.

Those erect dials, whose planes directly front the north or south, are called direct north or south dials; and all other erect dials are called decliners, because their planes are turned away from the north or south.

Those

Those dials, whose planes are neither parallel nor perpendicular to the plane of their horizon, are called inclining or reclining dials, according as their planes make acute or obtuse angles with the horizon; and if their planes are also turned aside from facing the south or north, they are called declining-inclining or declining-reclining dials.

The intersection of the plane of the dial, with that of the meridian, passing through the stile, is called the meridian of the dial, or the hour-line of XII.

Those meridians, whose planes pass through the stile, and make angles of 15, 30, 45, 60, 75, and 90 degrees with the meridian of the place (which marks the hour-line of 12), are called hour-circles; and their intersections with the plane of the dial, are called hour-lines.

In all declining dials, the substile makes an angle with the hour-line of XII; and this angle is called the distance of the substile from the meridian.

The declining plane's difference of longitude, is the angle formed at the intersection of the stile and plane of the dial, by two meridians; one of which passes through the hour-line of XII, and the other through the substile.

We shall now proceed to explain the different principles of their construction.

The universal Principle on which Dialling depends.

If the whole earth *a P c p* (Plate X. fig. 1) were transparent and hollow, like a sphere of glass, and had its equator divided into twenty-four equal parts by so many meridian semicircles, *a, b, c, d, e, f, g,* &c. one of which is the geographical meridian of any given place, as London (which is supposed to be at the point *a*); and if the hours of XII were marked at the equator, both upon that meridian and the opposite one, and all the rest of the hours in order on the rest of the meridians; those meridians would be the hour-

hour-circles of London: then, if the sphere had an opake axis, as P E p, terminating in the poles P and p, the shadow of the axis would fall upon every particular meridian and hour, when the sun came to the plane of the opposite meridian, and would consequently shew the time at London, and at all other places on the meridian of London.

Horizontal Dial.

If this sphere was cut through the middle by a solid plane A B C D, in the rational horizon of London, one half of the axis E P would be above the plane, and the other half below it; and if straight lines were drawn from the centre of the plane, to those points where its circumference is cut by the hour-circles of the sphere, those lines would be the hour-lines of a horizontal dial for London: for the shadow of the axis would fall upon each particular hour-line of the dial, when it fell upon the like hour-circle of the sphere.

Vertical Dials.

If the plane which cuts the sphere be upright, as A F C G (fig. 2), touching the giving place (London) at F, and directly facing the meridian of London, it will then become the plane of an erect direct south dial; and if right lines be drawn from its centre E, to those points of its circumference where the hour-circles of the sphere cut it, these will be the hour-lines of a vertical or direct south dial for London, to which the hours are to be set as in the figure (contrary to those on a horizontal dial); and the lower half E p of the axis will cast a shadow on the hour of the day in this dial, at the same time that it would fall upon the like hour-circle of the sphere, if the dial-plane was not in the way.

Inclining and reclining Dials.

If the plane (still facing the meridian) be made to incline, or recline, by any given number of degrees, the hour-circles of the sphere will still cut the edge of the plane in those points to which the hour-lines must be drawn straight from the centre; and the axis of the sphere will cast a shadow on these lines at the respective hours. The like will still hold, if the plane be made to decline by any given number of degrees from the meridian, towards the east or west; provided the declination be less than ninety degrees, or the reclination be less than the co-latitude of the place; and the axis of the sphere will be a gnomon, or stile, for the dial. But it cannot be a gnomon, when the declination is quite ninety degrees, nor when the reclination is equal to the co-latitude; because, in these two cases, the axis has no elevation above the plane of the dial.

And thus it appears, that the plane of every dial represents the plane of some great circle upon the earth; and the gnomon the earth's axis; whether it be a small wire, as in the above figures, or the edge of a thin plate, as in the common horizontal dials.

The whole earth, as to its bulk, is but a point, if compared to its distance from the sun: and therefore, if a small sphere of glass be placed upon any part of the earth's surface, so that its axis be parallel to the axis of the earth; and the sphere have such lines upon it, and such planes within it, as above described; it will shew the hours of the day as truly as if it were placed at the earth's centre, and the shell of the earth were as transparent as glass. See figs. 1 and 2.

But because it is impossible to have a hollow sphere of glass perfectly true, blown round a solid plane; or if it was, we could not get at the plane within the glass to set it in any given

given position; we make use of a wire sphere to explain the principles of dialing, by joining twenty-four semicircles together at the poles, and putting a thin flat plate of brass within it.

Dialling by the common Terrestrial Globe.

A COMMON globe, of twelve inches diameter, has generally twenty-four meridian semicircles drawn upon it. If such a globe be elevated to the latitude of a given place, and turned about until any one of these meridians cuts the horizon in the north point, where the hour of XII is supposed to be marked; the rest of the meridians will cut the horizon at the respective distances of all the other hours from XII. Then, if these points of distance be marked on the horizon; and the globe be taken out of the horizon, and a flat board or plate be put into its place, even with the surface of the horizon; and if straight lines be drawn from the centre of the board, to those points of distance on the horizon which were cut by the twenty-four meridian semicircles; these lines will be the hour-lines of a horizontal dial for that latitude, the edge of whose gnomon must be in the very same situation that the axis of the globe was, before it was taken out of the horizon: that is, the gnomon must make an angle with the plane of the dial, equal to the latitude of the place for which the dial is made.

If the pole of the globe be elevated to the co-latitude* of the given place, and any meridian be brought to the north point of the horizon, the rest of the meridians will cut the horizon in the respective distances of all the hours from XII, for a direct south dial, whose gnomon must make an angle with the plane of the dial, equal to the co-latitude of the

* If the latitude be subtracted from ninety degrees, the remainer is called the co-latitude, or complement of the latitude.

place; and the hours must be set the contrary way on this dial, to what they are on the horizontal.

But if your globe have more than twenty-four meridian semicircles upon it, you must take the following method for making horizontal and south dials by it.

To construct a Horizontal Dial.

ELEVATE the pole to the latitude of your place, and turn the globe until any particular meridian (suppose the first) comes to the north point of the horizon, and the opposite meridian will cut the horizon in the south. Then, set the hour-index to the uppermost XII on its circle; which done, turn the globe westward until fifteen degrees of the equator pass under the brasen meridian, and then the hour-index will be at I (for the sun moves fifteen degrees every hour); and the first meridian will cut the horizon in the number of degrees from the north point, that I is distant from XII. Turn on, until fifteen more degrees of the equator pass under the brasen meridian, and the hour-index will be then at II, and the first meridian will cut the horizon in the number of degrees that II is distant from XII: and so, by making fifteen degrees of the equator pass under the brasen meridian for every hour, the first meridian of the globe will cut the horizon in the distances of all the hours from XII to VI, which is just ninety degrees; and then you need go no farther; for the distances of XI, X, IX, VIII, VII, and VI, in the forenoon, are the same from XII, as the distances of I, II, III, IV, V, and VI, in the afternoon: and these hour-lines continued through the centre, will give the opposite hour-lines on the other half of the dial: but no more of these lines need be drawn, than what answer to the sun's continuance above the horizon of your place on the longest day, which may be easily found.

Thus,

Thus, to make an horizontal dial for the latitude of London, which is about $51\frac{1}{2}$ degrees north, elevate the north pole of the globe $51\frac{1}{2}$ degrees above the north point of the horizon, and then turn the globe, until the first meridian (which is that of London on the English terrestrial globe) cuts the north point of the horizon, and set the hour-index to XII at noon.

Then, turning the globe westward until the index points successively to I, II, III, IV, V, and VI, in the afternoon; or until 15, 30, 45, 60, 75, and 90 degrees of the equator pass under the brasen meridian, you will find that the first meridian of the globe cuts the horizon in the following numbers of degrees from the north towards the east, viz. $11\frac{2}{3}$, $24\frac{1}{4}$, $38\frac{1}{12}$, $53\frac{1}{2}$, $71\frac{1}{15}$, and 90; which are the respective distances of the above hours from XII upon the plane of the horizon.

To transfer these, and the rest of the hours, to a horizontal plane, draw the parallel right lines *a c* and *b d* (fig. 3) upon that plane, as far from each other as is equal to the intended thickness of the gnomon or stile of the dial, and the space included between them will be the meridian or twelve-o'clock line on the dial. Cross this meridian at right angles with the six-o'clock line *g h*, and setting one foot of your compasses in the intersection *a*, as a centre, describe the quadrant *g e* with any convenient radius or opening of the compasses; then setting one foot in the intersection *b* as a centre, with the same radius describe the quadrant *f h*, and divide each quadrant into ninety equal parts or degrees, as in the figure.

Because the hour-lines are less distant from each other about noon, than in any other part of the dial, it is best to have the centres of these quadrants at a little distance from the centre of the dial-plane, on the side opposite to XII, in order to enlarge the hour-distances thereabout under the same angles on the plane. Thus, the centre of the plane is at C, but the centres of the quadrants at *a* and *b*.

 Lay

Lay a ruler over the point *b*; and keeping it there for the centre of all the afternoon-hours in the quadrant *f h*; draw the hour-line of I, through $11\frac{2}{3}$ degrees in the quadrant; the hour-line of II, through $24\frac{1}{4}$ degrees; of III, through $38\frac{1}{12}$ degrees; IV through $53\frac{1}{2}$, and V through $71\frac{1}{15}$: and because the sun rises about four in the morning on the longest days at London, continue the hour-lines of IV and V, in the afternoon, through the centre *b* to the opposite side of the dial. This done, lay the ruler to the centre *a* of the quadrant *e g*, and through the like divisions or degrees of that quadrant, viz. $11\frac{2}{3}$, $24\frac{1}{4}$, $38\frac{1}{12}$, $53\frac{1}{2}$, and $71\frac{1}{15}$, draw the forenoon hour-lines of XI, X, IX, VIII, and VII; and because the sun sets not before eight in the evening on the longest days, continue the hour-lines of VII and VIII in the forenoon, through the centre *a*, to VII and VIII in the afternoon; and all the hour-lines will be finished on this dial; to which the hours may be set, as in the figure.

Lastly, through $51\frac{1}{2}$ degrees of either quadrant, and from its centre, draw the right line *a g* for the hypothenuse or axis of the gnomon *a g i*; and from *g*, let fall the perpendicular *g i*, upon the meridian line *a i*, and there will be a triangle made, whose sides are *a g*, *g i*, and *i a*. If a plate similar to this triangle be made as thick as the distance between the lines *a c* and *b d*, and set upright between them, touching at *a* and *b*; its hypothenuse *a g* will be parallel to the axis of the world, when the dial is truly set, and will cast a shadow on the hour of the day.

The trouble of dividing the two quadrants may be saved, by means of a scale with a line of chords upon it: for if we extend the compasses from 0 to 60 degrees of the line of chords; and with that extent, as a radius, describe the two quadrants upon their respective centres, the above distances may be taken with the compasses upon the line, and set off upon the quadrants.

To

To make an erect direct South Dial.

Elevate the pole to the co-latitude of your place, and proceed in all respects as above taught for the horizontal dial, from VI in the morning to VI in the afternoon; only the hours must be reversed, as in figure 4, and the hypothenuse *a g*, of the gnomon *a g f*, must make an angle with the dial-plane equal to the co-latitude of the place. As the sun can shine no longer on this dial, than from six in the morning until six in the evening, there is no occasion for having any more than twelve hours upon it.

To make an erect Dial, declining from the South towards the East or West.

Elevate the pole to the latitude of your place, and screw the quadrant of altitude to the zenith. Then if the dial declines towards the east (which we will suppose it to do at present), count in the horizon the degrees of declination, from the east point towards the north, and bring the lower end of the quadrant to that degree of declination at which the reckoning ends. This done, bring any particular meridian of your globe (as suppose the first meridian) directly under the graduated edge of the upper part of the brasen meridian, and set the hour-index to XII at noon. Then, keeping the quadrant of altitude at the degree of declination in the horizon, turn the globe eastward on its axis, and observe the degrees cut by the first meridian in the quadrant of altitude (counted from the zenith) as the hour-index comes to XI, X, IX, &c. in the forenoon, or as 15, 30, 45, &c. degrees of the equator pass under the brasen meridian at these hours respectively; and the degrees then cut in the quadrant by the first meridian, are the respective distances

tances of the forenoon hours from XII on the plane of the dial. For the afternoon hours, turn the quadrant of altitude round the zenith until it comes to the degree in the horizon opposite to that where it was placed before; namely, as far from the west point of the horizon towards the south, as it was set at first from the east point towards the north; and turn the globe westward on its axis, until the first meridian comes to the brasen meridian again, and the hour-index to XII: then, continue to turn the globe westward, and as the index points to the afternoon hours I, II, III, &c. or as 15, 30, 45, &c. degrees of the equator pass under the brasen meridian, the first meridian will cut the quadrant of altitude in the respective number of degrees from the zenith, that each of these hours is from XII on the dial. And note, that when the first meridian goes off the quadrant at the horizon, in the forenoon, the hour-index shews the time when the sun will come upon this dial: and when it goes off the quadrant in the afternoon, the index will point to the time when the sun goes off the dial.

Having thus found all the hour-distances from XII, lay them down upon your dial-plate, either by dividing a semicircle into two quadrants of ninety degrees, each beginning at the hour-line of XII, or by the line of chords.

In all declining dials, the line on which the stile or gnomon stands, commonly called the substile-line, makes an angle with the twelve-o'clock line, and falls among the forenoon hour-lines, if the dial declines towards the east; and among the afternoon hour-lines, when the dial declines towards the west; that is, to the left hand from the twelve-o'clock line in the former case, and to the right hand from it in the latter.

To find the Distance of the Substile from the Twelve-o'clock Line.

If your dial declines from the south towards the east, count the degrees of that declination in the horizon from the east point toward the north, and bring the lower end of the quadrant of altitude to that degree of declination where the reckoning ends: then, turn the globe until the first meridian cuts the horizon in the like number of degrees, counted from the south point towards the east; and the quadrant and first meridian will then cross one another at right angles; and the number of degrees of the quadrant which are intercepted between the first meridian and the zenith, is equal to the distance of the substile line from the twelve-o'clock line; and the number of degrees of the first meridian, which are intercepted between the quadrant and the north pole, is equal to the elevation of the stile above the plane of the dial.

If the dial declines westward from the south, count that declination from the east point of the horizon towards the south, and bring the quadrant of altitude to the degree in the horizon at which the reckoning ends; both for finding the forenoon hours, and the distance of the subtile from the meridian; and for the afternoon hours, bring the quadrant to the opposite degree in the horizon, namely, as far from the west towards the north, and then proceed in all respects as above.

Thus we have finished our declining dial: and in so doing, we made four dials, viz.

1. A north dial, declining eastward by the same number of degrees; 2. A north dial, declining the same number west; 3. A south dial, declining east; and 4. A south dial, declining west: only, placing the proper number of hours, and the stile or gnomon respectively, upon each plane. For, in the south-west plane, the substile line falls among the afternoon

afternoon hours: and in the south-east of the same declination, among the forenoon hours, at equal distances from XII. And so all the morning hours on the west decliner will be like the afternoon hours on the east decliner: the south east decliner will produce the north-west decliner; and the south-west decliner, the north-east decliner; by only extending the hour-lines, stile, and substile, quite through the centre: the axis of the stile, or edge that casts the shadow on the hour of the day, being in all dials whatever parallel to the axis of the world, and consequently pointing towards the north pole of the heavens in north latitudes, and towards the south pole in south latitudes.

An easy Method for constructing of Dials.

But because every one who would like to make a dial, may perhaps not be provided with a globe to assist him, and may probably not understand the method of doing it by logarithmic calculation: we shall shew how to perform it by the plain dialing-lines, or scale of latitudes and hours (see fig. 5). Scales of this kind are sold by all mathematical instrument-makers.

This is the easiest of all mechanical methods, and by much the best, when the lines are truly divided: not only the half hours and quarters may be laid down by all of them, but every fifth minute by most, and every single minute by those where the line of hours is a foot in length.

Having drawn a double meridian line *a b c d* (fig. 6), on the plane intended for an horizontal dial, and crossed it at right angles by the six-o'clock line *f e* (as in fig. 3), take the latitude of your place with the compasses, in the scale of latitudes, and set that extent from *c* to *e*, and from *a* to *f*, on the six-o'clock line; then, taking the whole six hours between the points of the compasses in the scale of hours, with that extent set one foot in the point *e*, and let the other foot

fall

fall where it will upon the meridian line *c d*, as at *d*. Do the same from *f* to *b*, and draw the right lines *c d* and *f b*, each of which will be equal in length to the whole scale of hours. This done, setting one foot of the compasses in the beginning of the scale at XII, and extending the other to each hour on the scale, lay off these extents from *d* to *e* for the afternoon hours, and from *b* to *f* for those of the forenoon; this will divide the lines *d e* and *b f* in the same manner as the hour-scale is divided, at 1, 2, 3, 4, 5, and 6; on which the quarters may also be laid down, if required. Then laying a ruler on the point *c*, draw the first five hours in the afternoon, from that point, through the dots at the numeral figures 1, 2, 3, 4, 5, on the line *d e*; and continue the lines of IV and V through the centre *c* to the other side of the dial, for the like hours of the morning; which done, lay the ruler on the point *a*, and draw the last five hours in the forenoon through the dots 5, 4, 3, 2, 1, on the line *f b*: continuing the hour-lines of VII and VIII through the centre *a* to the other side of the dial, for the like hours of the evening; and set the hours to their respective lines as in the figure. Lastly, make the gnomon the same way as taught above for the horizontal dial, and the whole will be finished.

To make an erect South Dial.

Take the co-latitude of the place from the scale of latitudes, and then proceed in all respects for the hour-lines as in the horizontal dial; only reversing the hours, as in fig. 2; and making the angle of the stile's height equal to the co-latitude.

A Dial

A Dial on a Card.

In fig. 9, we have the representation of a portable dial, which may be easily drawn on a card, and carried in a pocket-book. The lines *a d*, *a b*, and *b c*, of the gnomon, must be cut quite through the card; and as the end *a b* of the gnomon is raised occasionally above the plane of the dial, it turns upon the uncut line *c d* as on a hinge. The dotted line A B must be slit quite through the card; and the thread must be put through the slit, and have a knot tied behind, to keep it from being easily drawn out. On the other end of this thread is a small plummet D, and on the middle of it a small bead for shewing the time of the day.

To rectify this dial, set the thread in the slit right against the day of the month, and stretch the thread from the day of the month over the angular point where the curve-lines meet at XII; then shift the bead to that point on the thread, and the dial will be rectified.

To find the hour of the day, raise the gnomon (no matter how much or how little), and hold the edge of the dial next the gnomon towards the sun, so that the uppermost edge of the shadow of the gnomon may just cover the shadow-line; and the bead then playing freely on the face of the dial, by the weight of the plummet, will shew the time of the day among the hour-lines, as it is forenoon or afternoon.

To find the time of sun-rising and setting, move the thread among the hour-lines, until it either covers some one of them, or lies parallel betwixt any two; and then it will cut the time of sun-rising among the forenoon hours, and of sun-setting among the afternoon hours, on that day of the year for which the thread is set in the scale of months.

To find the sun's declination, stretch the thread from the day of the month over the angular point at XII, and it will cut

Horizontal Dial.

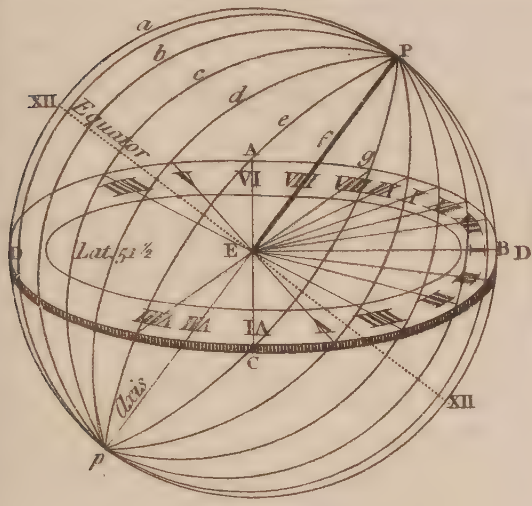


Fig. 1.

Vertical Dial.

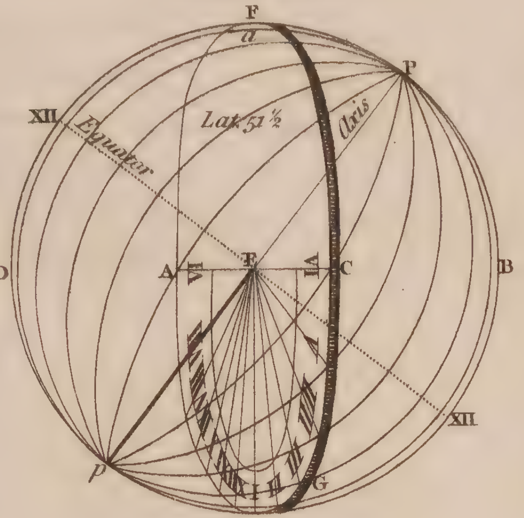


Fig. 2.

Horizontal Dial.

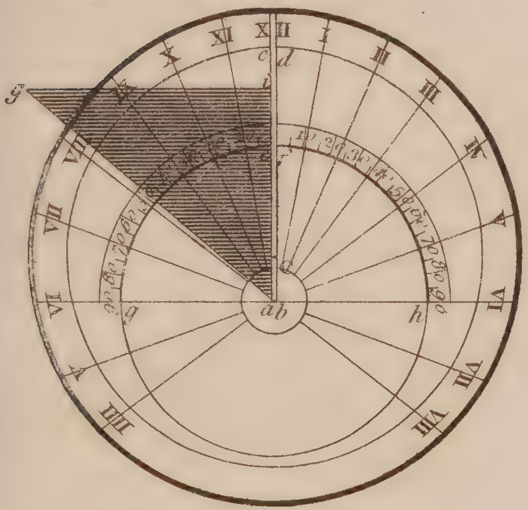


Fig. 3.

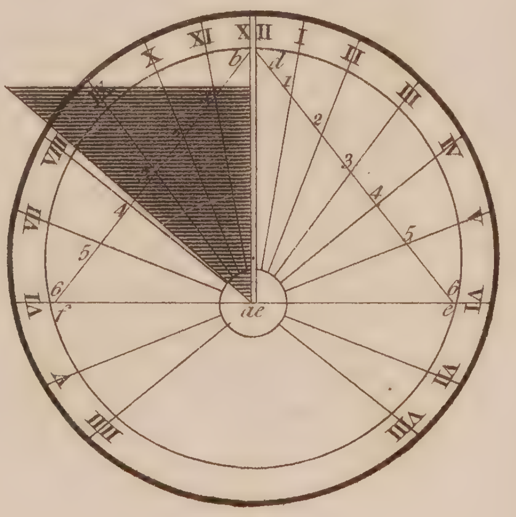


Fig. 6.

Erect South Dial.

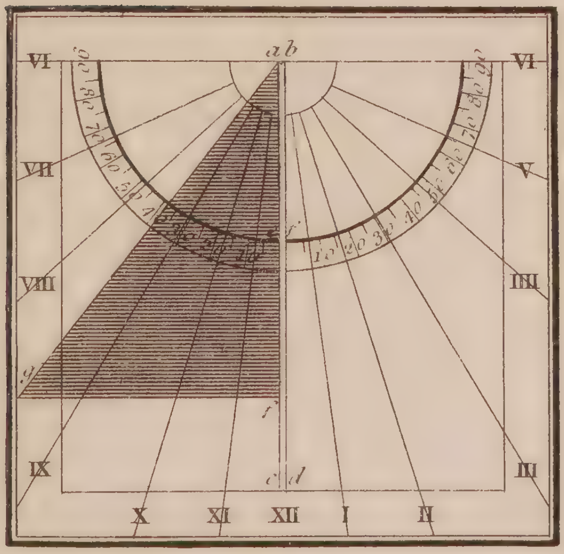


Fig. 4.

Portable Dial.

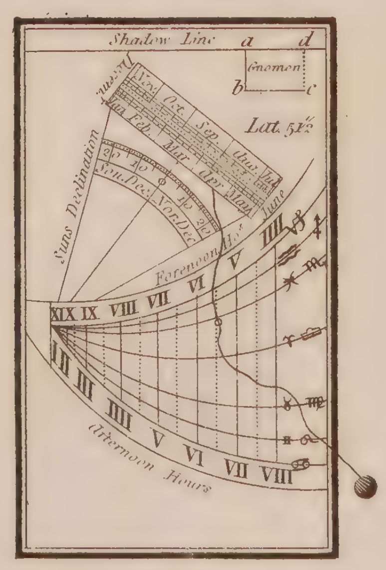


Fig. 9.

cut the sun's declination, as it is north or south, for that day, in the arched scale of north and south declination.

To find on what days the sun enters the signs; when the bead, as above rectified, moves along any of the curve lines which have the signs of the zodiac marked upon them, the sun enters those signs on the days pointed out by the thread in the scale of months.

PART

PART IX.

OPTICS AND OPTICAL EXPERIMENTS.

THE science of optics explains the nature of vision, by investigating the causes of the various phenomena that arise from the refraction and reflection of light. It is divided into Dioptrics, Catoptrics, and Chromatics *. The firsts treats of refraction; the second, of reflection; and the last, of colours.

General Definitions.

1. When the rays of light that issue from any body, continually recede from each other, as the rays AB and AC (Plate I. Fig. 1.) they are said to diverge.

2. When rays in their progress draw continually nearer to each other, as the rays BF and CF, (Plate XI. Fig. 1.) they are said to converge.

3. That point in which converging rays all meet, is called their focus; as the point F, in the same figure.

* These terms are derived from the Greek: the first from the word *dioptra*, a perspective glass; the second from *katoptron*, a mirror; and the last from *chromata*, colours.

4. An

4. An optic angle is the space contained between two lines drawn from the extremities of any object to the eye. Thus AEB or CED (Plate XI. Fig. 2.) are the optic angles under which the objects AB and CD appear to the eye at E.

Optical Axioms.

1. The motion of light is not instantaneous but progressive. It appears, by astronomical observations, that the rays of light are 8 minutes and 13 seconds in coming from the sun to the earth, which is distant about 82 millions of miles; their progress, therefore, is at the rate of about ten millions of miles in a minute; yet great as that velocity is, the distance of the nearest of the fixed stars being four hundred thousand times greater than that of the sun, the light must be more than six years in coming from them to us.

2. All rays of light naturally proceed in right lines.

3. No object can be seen distinctly at a less distance than about seven or eight inches.

4. To produce distinct vision, the rays of light must be parallel when they enter the eye, and the object well illumined.

5. Rays of light that come from a far distant object, are to be considered as parallel.

6. Wherever the rays that come from all the points of an object, meet again in so many points, after they have been made to converge by refraction or reflection, they will there form an image of that object on any white body.

7. Every object seen by refraction or reflection, appears to be in that point from whence its rays are last refracted or reflected to the eye.

8. The apparent magnitude of any object is determined by the magnitude of its optic angle: therefore the objects AB and CD, (Plate XI. Fig. 2.) which are seen under the same angle, will appear of equal magnitude.

9. A

9. A ray of light passing obliquely out of one medium into another that is denser, will be refracted toward the perpendicular, as the ray AB (Plate XI. Fig. 3.) by passing out of air into glass is refracted into CD, toward the perpendicular BF. On the contrary, a ray passing out of a denser into a rarer medium, will be refracted from the perpendicular; as the ray CD, passing out of glass into air, is rerefracted into DI.

10. The angles of incidence, and refraction, when the lines that contain them are all epual, will have a determinate proportion to each other, in the same mediums: which between air and water will be as 4 to 3; between air and glass, as 3 to 2, nearly; and in other mediums in proportion to their densities.

11. When an object is viewed through a glass whose two surfaces are parallel, it will appear of its natural dimensions, its situation only being a small matter altered in proportion to the thickness of the glass, and the obliquity of the rays.

12. All the rays of light, whether diverging, parallel, or converging, that fall on a single or double convex lens, will meet in a focus behind the glass; and the distance of that focus will be greatest in diverging, and least in converging rays.

13. When parallel or converging rays, fall on a single or double concave lens, they will diverge behind it. If they be diverging at their incidence, they will become more so by passing through it.

14. When an object is viewed through two convex lenses, its apparent length, or diameter, will be to its real length, as the distance of the focus of the object-glass, is to that of the eye-glass.

By these and the foregoing aphorisms, we are enabled to account for the various effects of dioptric machines, as refracting telescopes, microscopes, the camera obscura, &c.

But we intend in the place to give an account of some optical illusions and experiments that may afford entertainment to our younger readers.

We

We are all subject to mistake, into which we are led by our eyes, when the objects are out of the circle of our ordinary observation; and we are apt to deceive ourselves equally both as to magnitude and distance. Another cause that helps to impose upon us, is the diversity of positions which bodies assume with regard to us, arising either from the motions by which they are transported in space, or from those which we make ourselves. The circumstances which determine these errors, to which the name of optical illusions have been given, are extremely various; the sphere that embraces them is immense; they extend even to those vast bodies that revolve in the celestial regions, and the hypothesis relative to their influence on the manner in which many of the planetary phenomena exhibit themselves to our observation, is become the foundation of a theory that reduces these phenomena to a happy simplicity, which were before so embarrassing to persons desirous of seeing realities in their simple and genuine appearance. We shall explain some of these illusions, selected from such as are most familiar or best entitled to notice. There is no person probably who, standing at one of the extremities of a long avenue, has not observed that the two rows of trees of which it is formed appear to converge towards each other, so as even to touch, if the avenue be of sufficient length. In this case the intervals between the corresponding trees on each side subtend visual angles that regularly diminish, till at last they are insensible at a great distance. It follows from this, that in the small picture on the bottom of the eye, the images of the trees are situated on two lines that are inclined towards each other, and tend towards a common point; or, which amounts to the same, the interals between the images of the corresponding trees diminish gradually, in such manner that the last interval is almost nothing. Now if we suppose that the two optic axes direct themselves successively towards the different trees as they increase in distance, the variation of these angles, and at the same time that of the impression of the

 distance,

distance, will continually become less perceptible; and, by a necessary consequence, the impression of the magnitude, which depends here on the interval between the corresponding trees, will be so predominant, that it will nearly determine of itself the type of the sensation; so that two lines exactly parallel will present themselves to us under the aspect of two converging lines. It is owing to a similar cause that, when we are at the entrance of a long gallery, the ceiling appears to slope downwards a little, and the floor to rise. If it be a single plane only that is situated with respect to the eye like one of the planes in the preceding instance, as when we are at one end of a long piece of water, that plane will also appear to rise, more and more in proportion as the parts shall be remote from the spectator; for in this case he compares the plane with the line of the horizontal level, which passes through the eye and performs the office of a second plane, towards which the first seems to approach in consequence of the diminution of the visual angles that proceed from the corresponding points of each. If the spectator at the foot of a lofty tower looks to the summit, the tower, on the side on which he stands, will appear to incline; for he compares its position with a vertical line that passed through the eye; and accordingly this vertical and the height of the tower are two parallels that should tend in appearance to meet at the summit. In these cases the vertical line and the horizontal line are kinds of ideal limits to which the eye refers the visual angles, one of the sides of which is always one or other of these lines; in like manner nearly as, when we would estimate with the eye the inclination of a line existing in space, we compare it with an imaginary horizontal or vertical line that passes through one of the extremities of that line. There is another source of illusion with regard to vertical objects. In looking upwards, after inclining our heads all we can, we are apt to imagine that we have brought the axes of our eyes to point towards the zenith; but instead of this being the

case,

case, our eyes even then look forward many degrees from that point, so that whatever is in or near the zenith seems to hang over as many degrees behind us. And this accounts for the greater part of the mistakes that people generally are apt to be under, concerning the altitudes of stars having very high elevations.

When we are stationed at a certain distance from a rising ground, it appears to us longer than it would if it were on a level with the horizon; which is evident from the mere inspection of figure 5, where m n represents the inclined position of the ground, and its length m *a*, what it would be if it were horizontal, and n o m, *a* o m, the visual angles answering to the two positions. From the same principles, we shall be able to explain a multitude of other optical illusions, that must daily present themselves to the most inattentive observer. For example, if we are situated opposite the middle of a long line that is very remote from us, we shall observe it to inflect both to the right and left, so as to appear part of a curve, of which the axis passes through the eye. If we stand before a regular polygon of a certain extent, the sides that are parallel to the surface of our body will look larger than those which are oblique, and the polygon will have an irregular appearance. What we have said leads us to some considerations upon the subject of perspective. See Vol. II. The object of this science is to represent on a plane bodies of every form. Now, if, for greater simplicity, we suppose the body, of which we would trace the image, to be terminated by plane faces, the figures of these faces will necessarily differ from what they are on the body itself. If, for example, we would represent a cube, we shall be very well able to give the figure of a square to one of the faces of the image; but the two adjoining faces, which concur with the first in the formation of one and the same solid angle, will be evidently quadrilaterals of a different figure, since the sum of the three plane angles in question, considered in the image, ought to be equivalent to four

right angles, whereas they are only equal to three on the solid. Notwithstanding this difference, we fail not to succeed by a certain arrangement of lines which constitute a sort of illusion, and exhibit to the eye a faithful portrait of the original object. To understand the reason of this illusion, let us suppose a cube to be situated in space, in a given position relatively to the eye of the spectator, and let us also suppose it to be transparent. From what we have said of the manner in which vision is effected, it results that the axes of the different pencils of light transmitted from the different points of the cube, and which are the only lines we have occasion for here, after crossing one another in the aperture of the pupil, will form a kind of small pyramid, whose base will rest on the bottom of the eye, where it will produce the image of the cube. Now, let us suppose a plane, or transparent picture, parallel to the bottom of the eye, and through which all the axes pass that proceed from the different points of the cube to this eye, each leaving its impression there. The image formed by the whole of these impressions will be similar to that which will be painted at the bottom of the eye, allowance being made for the slight difference that must be occasioned by the curvature of this organ. Lastly, let us imagine the picture to become opaque, and that the image of the cube still exists in it; that which was at the bottom of the eye will be still the same, and its immediate object will be the first image, all the points of which will send to the eye rays situated precisely like those which came from the cube. Now such image is what is called the perspective of the cube. From this statement we conceive how the image, the traits of which are the same at the bottom of the eye as those which would be formed there by the rays proceeding from the different points of the cube, must represent this cube as faithfully as the level of the plane which serves as canvas to the picture would permit. Geometry furnishes rules for tracing the lines that form as it were the sketch of these kinds of portraits; and when to this sketch, which posseses in itself a striking resemblance, the

art

art of painting adds the distinction of light and shade, and the magic of colouring, there results from the whole an illusion that is nearly perfect, and that wants only a little management of the eye to excite all the pleasure of surprise. One of the most remarkable optical illusions is that which leads us to suppose the moon to be larger when it rises, than it is when at a certain height above the horizon. We must all have frequently been struck with the contrast which the diameter of this luminary exhibits, when compared with itself in the two situations we have mentioned. To understand the cause of this we must reason from the principle that we see the sky in the form of a very depressed vault, much less than a hemisphere. Let T (fig. 6) be the half of the terrestrial globe elevated above the horizon u x; u y t x half the circle through which the moon passes in its diurnal motion, and a c g b the corresponding half of the curve which bounds the sensible part of the hemlsphere. The different strata of which the atmosphere is composed, reflect in preference the blue rays of the light of the sun, and they are the rays passing to the eye that occasion the medium to appear to us of that colour. The surface a c g b, which represents the limit to which all these reflections extend, thus appears to our eyes like a vault, to which all the stars seem to be attached. Let us suppose a spectator placed at the point o, and let us draw from this point a plane, p o i, parallel to u x. The spectator, to whom the curvature of the earth is imperceptible, will be circumstanced precisely as if this plane really existed, and thus the celestial vault will be reduced in his estimation to the arch d c g e, which rests on the same plane; from which it follows, that the extreme points, d, e, of this vault will be seen by him at a much greater distance than the culminating point l. On the other hand, the objects that are interposed between us and the moon, when this luminary is at the horizon, contribute still further to increase the apparent distance of the points, d, e, with regard to the spectator, and to diminish the curvature that he ascribes to the celestial vault. Let us suppose f l h to be a section of

this vault, such as it appears to us from the double effect we have mentioned. The arches p u, i x, being deemed infinitely small, on account of the great distance of the moon from us, the instant its centre arrives at n may be considered, without palpable error, as that of its rising. The spectator then sees it under the angle p o r, and refers it to L, at the distance o f. When the moon is afterwards arrived at z, that is, at the meridian, the spectator sees it still under the same angle, p′ o r′, but refers it to l, that is, to a point that is much nearer to him; accordingly, though the image of the moon always occupies the same space in the eye of the spectator, yet as that luminary appears to be at a smaller distance, he judges it to be smaller, in the proportion nearly of o l to o f; for then the two products that result from the impression of the magnitude, combined with that of the distance, having a common quantity, which is the first impression, are in some sort proportional to the second; and thus we form an idea of the real magnitude, from the proportion between the apparent distances. Mallebranche, to whom, in great measure, we are indebted for this explanation, has verified it by an experiment, both simple in itself and easily made, which is by looking at the moon in the horizon through a piece of smoked glass. In this case it appears no larger than when at its meridian height, if the glass be placed so near to the eye as completely to eclipse all other objects, and afford no opportunity of estimating distances. We shall now proceed to optical illusions, that have their source in motion. Let us conceive first an immoveable object, and a spectator who moves, from the left to the right, for example, but in such a manner that he is not conscious of it. The object in this case being continually more to the left with regard to the spectator, his eye will receive the same impression as it would have done, if, immoveable himself, he had seen motion communicated to the object from the right to the left. In general, when we move without perceiving it, we refer such motion in a contrary sense to the objects about us.

Thus,

Thus, when we are at rest in a boat that is in motion, we see the trees, buildings, and other objects, approach, pass before us, and remove to a distance, accordingly as the boat is rowed in opposite directions. The hypothesis of a spectator, when in motion himself, without being conscious of it, ascribing the motion in a contrary sense to objects that are at rest, enables us to explain the apparent diurnal motion of the sun, in cousequence of the real motion of the earth round its axis; and upon the same principle we may account for the annual motion which the sun appears to have in the ecliptic; while the other hypotheses, relative to the simultaneous motion of the spectator and some object before his eyes, have furnished the true cause of the seeming irregularities in the periodical revolutions of the planets, accordingly as they are thought to take a retrograde course in their orbits, or to move with increased velocity, or to remain stationary for a time. When, while we are running, we look at an object that is at a great distance, and has no motion, or none but what is imperceptible to us, it seems as if the object ran with us, and in the same direction; as, for example, when in running we look at the moon. The visual ray, constantly directed towards that luminary, forms with it in this case, on account of the immense distance, such small angles, in proportion as it changes its direction, that the directions are to the senses parallel to one another, so that the moon appears to move at the extremity of that ray; and as we have the sentiment of the motion which the eye makes, from which the same ray proceeds, we ascribe a similar motion to the moon.

The curious phenomenon of accidental colours, first attended to by Buffon, deserves some mention under the head of optical illusions. The phenomenon is this: If a person look stedfastly, and for a considerable time, at a small red square, painted upon white paper, he will at last observe a kind of green coloured border surround the red square. If he now turn his eyes to some other part of the paper, he will see

an

an imaginary square of a delicate green, bordering on blue, and corresponding exactly in point of size with the red square. This imaginary square continues visible for some time, and indeed does not disappear till the eye has viewed successively a number of new objects. To this imaginary square the name of accidental colour has been given. If the square be yellow, the accidental colour is blue; the accidental colour of green is red; of blue, yellow; of white, black, while, on the contrary, that of black is white. And in general, the accidental colour is the colour resulting from the mixture of all the rays of light, those rays excepted which are the same with the primitive colour.

EXPERIMENT I.

On the bottom of the vessel A B C D, as an earthen pan, (fig. 7) place three pieces of money, as a shilling, a half-crown, and crown; the first at E, the second at F, and the last at G. Then place a person at H, where he can see no farther into the vessel than I: and tell him that by pouring water into the vessel you will make him see three different pieces of money; bidding him observe carefully whether any money goes in with the water *.

When the water comes up to K, the piece at E will become visible; when it comes up to L, the pieces at E and F will appear; and when it rises to M, all the three pieces will be visible.

From what has been said of the refraction of light, the cause of this phenomenon will be evident: for while the vessel is empty, the ray H I will naturally proceed in a straight line: but in proportion as it becomes immersed in water, it will be necessarily refracted into the several directions

* You must either pour it in very gently, or contrive to fix the pieces by means of wax, that they may not move out of their places by the motion of the water.

tions N E, O F, P G, and consequently the several pieces must become visible.

EXPERIMENT II.

TAKE a drinking glass, a goblet, in which put a shilling, and fill the glass about half full with water: then place a plate on the top of it, and turn it quickly over, that the water may not get out. You will then see on the plate, a piece of the size of a half-crown; and somewhat higher up, another piece of the size of a shilling.

This phenomenon arises from seeing the piece through the conical surface of the water at the side of the glass, and through the flat surface at the top of the water, at the same time: for the conical surface dilates the rays and makes the piece appear larger; but by the flat surface the rays are only refracted, by which the piece is seen higher up in the glass, but still of its natural size. That this is the cause will be farther evident by filling the glass with water, for as the shilling cannot be then seen from the top, the large piece only will be visible.

After you have amused yourself with this remarkable phenomenon, you may give the glass to a servant, telling him to throw out the water, and take care of the two pieces of money; and if he have no suspicion of the deception, he will be not a little surprised to find one piece only.

EXPERIMENT III.

AGAINST the wainscot of a room fix three small pieces of paper, as A B C, (fig. 8) at the height of your eye; and placing yourself directly before them, at a few yards distance, shut your right eye and look at them with the left; when you will see only two of those papers, suppose A and B; but altering

altering the position of your eye you will then see the third and one of the first, suppose A; and by altering your position a second time, you will see B and C; but never all three of them together.

The cause of this phenomenon is, that one of the three pencils of rays that come from these objects, falls on the optic nerve at D; whereas to produce distinct vision it is necessary that the rays of light fall on some part of the retina E, F, G, H. We see by this experiment, one of the uses of having two eyes; for he that has one only, can never see three objects placed in this position, nor all the parts of one object of the same extent, without altering the situation of his eye.

EXPERIMENT IV.

With a convex lens of about an inch focus, look attentively at a silver seal, on which a cypher is engraved. It will at first appear cut in, as to the naked eye; but if you continue to observe it some time, without changing your situation, it will seem to be in relief, and the lights and shades will appear the same as they did before. If you regard it with the same attention still longer, it will again appear to be engraved: and so on alternately.

If you look off the seal for a few moments, when you view it again, instead of seeing it, as at first, engraved, it will appear in relief.

If, while you are turned toward the light, you suddenly incline the seal, while you continue to regard it, those parts that seemed to be engraved will immediately appear in relief: and if, when you are regarding these seeming prominent parts, you turn yourself so that the light may fall on the right hand, you will see the shadows on the same side from whence the light comes, which will appear not a little extraordinary. In like manner the shadows will appear on the left, if the light fall on that side. If instead of a seal you look

look at a piece of money, these alterations will not be visible, in whatever situation you place yourself.

It has been suspected that this illusion arises from the situation of the light; and in fact I have observed (says M. Guyot) that when I have viewed it with a candle on the right, it has appeared engraved, but by changing the light to the left side, it has immediately appeared in relief. It still, however, remains to be explained, why we see it alternately hollow and prominent, without changing either the situation or the light. Perhaps it is in the sight itself that we must look for the cause of this phenomenon; and this seems the more probable, as all these appearances are not discernible by all persons.

A phenomenon like this will appear to a superficial observer a very trifling matter: but the philosopher, who is desirous of explaining all the appearances of nature, will find it attended with no trifling difficulties. It is, moreover, by investigating the causes of phenomena seemingly insignificant, that the most important discoveries are sometimes made.

EXPERIMENT V.

The Camera Obscura, or Dark Chamber.

We shall here give a short description of this optical invention; for though it is very common, it is also very pleasing, and though almost every one has seen it, every one knows not how to construct it.

Make a circular hole in the shutter of a window, from whence there is a prospect of the fields, or any other object not too near; and in this hole place a convex glass, either double or single, whose focus is at least five or six feet, and not longer than twelve feet. Take care that no light enter the room but by the glass: at a distance from it, equal to that of its focus, place a pasteboard, covered with the whitest paper;

paper; let it be two feet and a half long, and eighteen or twenty inches high: bend the length of it inwards, to the form of part of a circle, whose diameter is equal to double the focal distance of the glass. Then fix it on a frame of the same figure, and put it on a moveable foot, that it may be easily fixed at that exact distance from the glass where the objects paint themselves to the greatest perfection. When it is thus placed, all the objects that are in the front of the window will be painted on the paper, in an inverted position*, with the greatest regularity and in the most natural colours.

If you place a moveable mirror without the window, by turning it more or less, you will have on the paper all the objects that are on each side of the window.

If, instead of placing the mirror without the window, you place it in the room, and above the hole (which must then be made near the top of the shutter), you may receive the representation on a paper placed horizontally on a table; and draw at your leisure, all the objects that are there painted.

Nothing can be more pleasing than this experiment, especially when the objects are strongly enlightened by the sun: and not only land prospects, but a sea-port, when the water is somewhat agitated, or at the setting of the sun, presents a very delightful appearance.

This representation affords the most perfect model for painters, as well for the tone of colours, as that gradation of

* This inverted position of the images may be easily remedied: for if you stand above the board on which they are received, and look down on it, they will appear in their natural position: or if you stand before it, and placing a common mirror against your breast in an oblique direction, look down in it, you will there see the images erect, and they will receive an additional lustre from the reflection of the glass; or place two lenses, in a tube that draws out; or lastly, if you place a large concave mirror at a proper distance before the picture, it will appear before the mirror, in the air, and in an erect position.

shades,

shades, occasioned by the interposition of the air, which has been so justly expressed by some modern painters.

There is another method of making the dark chamber, which is by a scioptric ball; that is, a ball of wood, through which a hole is made, in which hole a lens is fixed: this ball is placed in a wooden frame, in which it turns freely round. The frame is fixed to the hole in the shutter, and the ball, by turning about, answers, in great part, the use of the mirror on the outside of the window. If the hole in the window be no bigger than a pea, the objects will be represented without any lens.

EXPERIMENT VI.

To shew the Spots on the Sun's Disk, by its Image in the Camera Obscura.

Put the object-glass of a ten or twelve foot telescope into the scioptric ball, and turn it about till it be directly opposite the sun *. Then place the pasteboard, mentioned in the last Experiment, in the focus of the lens, and you will see a clear bright image of the sun, of about an inch diameter, in which the spots on the sun's surface will be exactly described.

As this image is too bright to be seen with pleasure by the naked eye, you may view it through a lens, whose focus is six or eight inches distant, which at the same time that it prevents the light from being offensive, will, by magnifying both the image and the spots, make them appear to greater advantage.

* When the sun is directly opposite the hole the lens will itself be sufficient: or by means of the mirror on the outside of the window, as in the fifth Experiment, the lens will answer the purpose at any time.

EXPERIMENT VII.

To magnify small Objects by means of the Sun's Rays let into a dark Chamber.

LET the rays of light that pass through the lens in the shutter be thrown on a large concave mirror, properly fixed in a frame. Then take a slip, or thin plate of glass, and sticking any small object on it, hold it in the incident rays, at a little more than the focal distance from the mirror, and you will see, on the opposite wall, amidst the reflected rays, the image of that object, very large, and extremely clear and bright. This experiment never fails to give the spectator the highest satisfaction.

EXPERIMENT VIII.

The Magic Lantern.

THIS very remarkable machine, which is now known over all the world, caused great astonishment at its origin. It is still beheld with pleasing admiration, and the spectator very frequently contents himself with wondering at its effects, without endeavouring to investigate their cause. The invention of this ingenious illusion is attributed to the celebrated P. Kircher, who has published, on various sciences, works equally learned, curious, and entertaining.

The design of this machine is to represent at large, on a cloth or board, placed in the dark, the images of small objects, painted with transparent colours on plates of glass.

Its construction is as follows. Let ABCD (fig. 9), be a tin box, eight inches high, ten long, and six wide (or any other similar dimensions. At the top must be a funnel E, of

of four inches in diameter, with a cover F, which, at the same time that it gives a passage to the smoke, prevents the light from coming out of the box.

On the side A C there is a door, by which is adjusted a concave mirror G, of metal or tin, and of five inches diameter; being part of a sphere whose diameter is eighteen inches, this mirror must be so disposed that it may be pushed forward or drawn back by means of the handle H, that enters the tin tube I, which is soldered to the door.

In the middle of the box must be placed a low tin lamp K, which is to be moveable. It should have three or four lights, that must be at the height of the focus of the mirror G.

In the side B D, and opposite to the mirror, there must be an aperture of three inches wide, and two inches and a half high, in which is to be fixed a convex glass L, of the same dimension*, whose focus must be from four inches and a half to five inches, so that the lamp may be placed both in its focus, and in that of the concave mirror.

On the same side place a piece of tin M N, of four inches and a half square, having an opening at the sides of about four inches and a half high, and a quarter of an inch wide. Through this opening or groove are to pass the glasses, on which are painted the figures that are to be seen on the cloth. In this tin piece, and opposite the glass L, let there be an aperture of three inches and a quarter long, and two inches and a quarter high, to which must be adjusted a tube O, of the same form, and six inches long. This tube is to be fixed into the piece M N. Another tube, six inches long, and moveable, must enter that just mentioned, in which must be placed two convex lenses, P and Q; that of P may have a

* I prefer this form for the glass (says M. Guyot) that the picture thrown upon the cloth may have the same form, which is much preferable to a circular aperture, through which the figures can never be completely seen but when they are at the centre of the glass. It is surprising that this imperfection has been suffered to continue so long, when it is so easily remedied.

focus

focus of about three inches, and that of Q, which is to be placed at the extremity of the tube, one of ten or twelve inches. The distance between these glasses is to be regulated by their foci. Between these glasses there must be placed a pasteboard R, in which is an aperture of an inch wide, and 4-5ths of an inch high. By placing this tube farther in or out of the other, the images on the cloth will appear larger or smaller.

From what has been said of the preceding machines, the construction of this will be easily understood. The foci of the concave mirror, and the lens L, meeting in the flame of the lamp, they together throw a strong light on the figures painted on the glasses that pass through the groove M N, and by that means render their colours distinct on the cloth. The rays from those glasses passing through the lens P are collected by the aperture in the pasteboard R, and conveyed to the lens Q, by which they are thrown on the cloth.

The lantern being thus adjusted, you must provide plates of clear glass, of twelve or fifteen inches long, and three inches wide, which are to be placed in thin frames, that they may pass freely through the groove M N, after being painted in the manner we shall now describe.

Method of Painting the Glasses for the Lantern.

DRAW on a paper the subject you intend to paint, and fix it at each end to the glass. Provide a varnish with which you have mixed some black paint, and with a fine pencil draw on the other side of the glass, with very light touches, the design drawn on the paper. If you are desirous of making the painting as perfect as possible, you should draw some of the outlines in their proper colours, provided they are the strongest tints of those colours that are used. When the outlines are dry, you colour the figures with their proper tints or gradations; and those colours will not peel off, if you

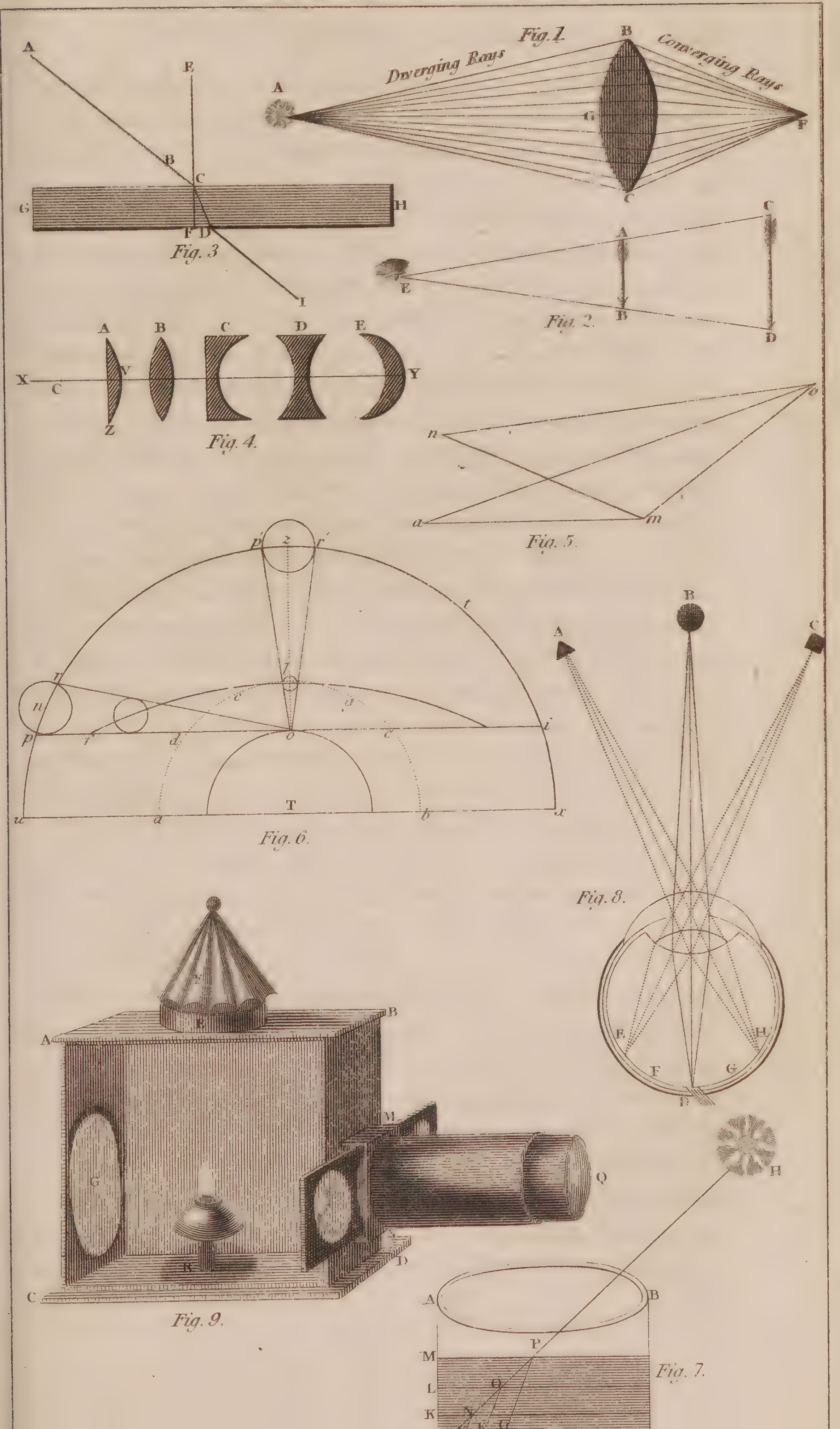


Fig. 1.

Fig. 2.

Fig. 3

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

temper them with a strong white varnish. You are then to shade them with black, mixed with the same varnish, or white bistre, as you find convenient. You may also leave strong lights in some parts without any colours, in order to produce a more striking effect. Observe, in particular, not to use more than four or five colours, such as blue, red, green, and yellow. You should employ however a great variety of tints, to give your painting a more natural air, without which they will represent vulgar objects, which are by no means the more pleasing because they are gaudy.

When the lamp in this lantern is lighted, and by drawing out the tube to a proper length, the figures painted on the glass appear bright and well defined, the spectator cannot fail of being highly entertained by the succession of natural or grotesque figures that are painted on the glasses.

This piece of optics may be rendered much more amusing, and at the same time more marvellous, by preparing figures to which different natural motions may be given, which every one may perform according to his own taste; either by movements in the figures themselves, or by painting the subject on two glasses, and passing them at the same time through the groove.

Philosophers, by modifying the construction and operation of the magic lantern, have transformed it into an instrument capable of producing a much more imposing effect, to which they have given the name of Phantasmagoria. Here the mechanism of the operation is concealed from the spectators, who have only before their eyes a skreen of gauze or gummed muslin, posited vertically, which serves as the ground of a picture, where the images are depicted by reason of the transparency. The apartment is deprived of all light except that which proceeds from an apparatus hid behind the skreen. At the moment when the operation commences, a spectre appears (as of a skeleton, the head of a celebrated person, &c.) at first extremely small, but which afterwards increases rapidly, and thus seems to advance at a great rate towards

towards the spectators: and when the scene passes before them in a room representing a cave hung with black, a solemn silence being occasionally interrupted by mournful sounds from an appropriate musical instrument, it is not easy for an observer to defend himself from the impression of terror, at the sight of an object in itself formed to produce the illusion, and which finds in the imagination a place already prepared for the reception of phantoms. The instrument placed behind the gauze skreen is in fact a peculiar construction of the magic lantern: only in the former it is necessary that the lenses should run over a much greater space, and that the instrument may be susceptible of approaching to, and receding from, the frame of gauze, in such manner that each luminous pencil may be depicted there in a single point. The general construction is this: In a square box a lamp is placed, the luminous rays proceeding from which are reflected by a conical mirror towards an orifice made in the box. At this orifice is placed a tube blackened within, and composed of several tubes, which slide one into another, like those of a pocket telescope. This tube is furnished with two bi-convex lenses of about five inches diameter: one of these is fixed, the other is at the outer extremity of the tube, and is separated from the former in proportion as the tube is lengthened by the aid of a hooked lever, situated along the tube between the lamp and the lenses. A groove is properly adapted to the tube destined to receive transparent figures: lastly, the box rests upon a table moveable on four wheels, that slide in two channels perpendicularly to the frame on which the images are depicted. It is manifest that we may augment or diminish the dimensions of the images, and consequently make the spectre appear more or less near to the spectator, by separating farther, or by bringing nearer together, the two lenses; but then the focus of the diverging rays which proceed from the same point of the transparent body will be no longer upon the skreen: we must therefore cause the machine so to re-

cede

cede or approach that the two motions being duly combined the image may be distinctly formed. These phantasmagoria are furnished with a great number of transparencies, in each of which several changes may be made by slackening their springs: thus we may change at every instant, the form, the magnitude, and the distance of the spectres, as they appear to the spectator. What has been said hitherto relates only to the images of transparent figures. To obtain those of opaque bodies, first place the gauze and box, at the distance of about six feet one from the other, and adapt to the orifice of the box an apparatus of two tubes furnished with two bi-convex lenses: an opaque body, such, for example, as a medal, or a picture, is attached to a little support posited in the middle of the box; the lamp and its supply of air situated in one of the foremost corners of the box, illuminates that object, and the reflected rays crossing the lenses proceed till they trace the image upon the gauze, with an amplification which is in the ratio of the distances. If the image be not distinct, we must infer that it is not at the focus; but it may be adjusted in three different ways: 1. By moving the box to or from the gauze; 2. By moving the object nearer to, or farther from, the lenses within the box; 3. By slowly moving the tubes to cause a variation in the distance between the lenses.

PART X.

STENOGRAPHY;

OR

THE ART OF SHORT-HAND WRITING.

PREVIOUSLY to entering upon the immediate subject of Short-hand Writing, it will be proper here to class a very useful and valuable invention, partaking in some measure of the nature of symbolical characters, and therefore affording a neat introduction to that important art.

The nature of the plan alluded to may be thoroughly comprehended by its name, which includes a complicated range of accompts, in a way the most simple, convenient and intelligible:—it is termed

THE UNIVERSAL REGULATOR OF WORK AND WORKMEN.

THOSE who have the direction of many servants, or of various sorts of workmen, viz. stewards, builders, tradesmen, and the overseers of workmen, find themselves liable to mistakes

Accompt kept by Jonathan Dilkes the Steward.

PLATE XII.

WORKMENS NAMES.	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	*Rate per Day.*	*Numbr. of Days*	*Amount L.*	*S.*	*D.*	*Remarks & Memorandums*
John Smith.	○	+	+			+	2"	2 1/4		4	6	
Thomas Webb.							1" 6	1 1/2		2	3	
Joseph Walker.			+		+		2" 6	2		5		*Lent J.W. one Shilling*
James Frith.							1" 6	1 1/4		1	10 1/2	
William Evans.					+	+	1"	1		1		*Work ill done*

EXPLANATION

○ *The Whole Day employed.*

The Forenoon of the Day.

The Afternoon do.

The First Quarter do.

The Second Quarter do.

Third Quarter do.

Fourth Quarter do.

First & Third Quarter do.

Second & Fourth Quarter.

First & Fourth Quarter

Second & Third Quarter.

The First Three Quarters.

The Last Three Quarters.

First Third & Fourth Quarters.

First Second & Fourth Quarters.

\+ *The Whole Day Idle.*

takes and inconveniences; for which reason they should adopt a regular and uniform method of keeping their accompts. Gentlemen also should be able to avoid a great deal of perplexity, which daily arises from a want of arrangement in their accompts, among the labourers, gardeners, hay-makers, and others whom they must necessarily employ in their rural and agricultural improvements.

The whole scheme is so simple, that the mere inspection of *plate* XII, will completely exemplify the plan. By means of *a circle and a cross,* disposed in ruled columns, properly arranged, all the *names of the workmen, and the length of time they severally worked, in each day,* together with *the money due to them on the completion of the week,* and the *good or bad qualities of the work and the workman,* are to be seen at one view.

The next article will contain a short, easy, and effectual system of

SHORT-HAND WRITING.

This art was known and practised by the Egyptians, who were distinguished for learning at an early period, as may be known by their *hieroglyphics.* But the moderns have simplified the art, and have brought it to a degree of perfection, which has rendered it highly useful, and within the sphere of the meanest capacity.

A variety of systems have been from time to time published, differing in the shapes and forms of their characters, but maintaining one general principle, viz. the substitution of symbols and contractions, expressive of letters, and even whole words, in lieu of the ordinary alphabet, which is too prolix and difficult for swift writing. If one system be preferable to another, that should be adopted which admits of *most contraction, with easy and rapid execution, and with legibility without perplexity.* Such a system is perhaps

best attained by leaving the more nice and subtle parts to the opinion of each practitioner, to supply or reject what may suit his ideas and his penmanship; a few plain rules, therefore, will be here set down, with a list of such characters or symbols as appear simple in their structure, and admit of convenient junction; together with such abbreviations or contractions as, on further practice, may be received.

Rule 1. Leave out all unnecessary vowels, without which the words would be too long to allow of copying a rapid speech; thus *Dvd* for *David*, &c.

Rule 2. Every word should be finished without taking off the pen; otherwise great confusion will arise by the symbols being occasionally scrambled out of their places.

Rule 3. Use no more letters in spelling a word than will be sufficient to sound it: the proper mode of spelling may be adopted when it is transcribed into long-hand.

Rule 4. Few stops are required, except to divide one complete sentence from another, as is practised constantly in legal instruments: for this, a *cross* may be adopted.

Rule 5. Change any letter for another, where convenient; thus, *F* may be substited for *V*, and the contrary, they being so much alike in sound; so may *F* for *Ph*.

Rule 6. Omit useless consonants; thus, *G* may be dropped before *n* as in *G*nat; and *b* may be dropped after *m*, as in lam*b*, com*b*. So may other consonants be omitted, provided the sense be not obscured.

When the above rules are observed, and perfectly acquired, together with the simple characters and their joinings,

Substitute Characters

PLATE XIII

b	be, by, been, bee.
d	do, did, didst, had, hadst.
f or v	off, of, if, fee, fast.
g or j	God give go ago.
h	have, he, history.
k or q	known, know, king, could.
l	lord, lie, all, live, will, line.
m	me, my, man, many, ments.
n	hand, and, an, in, no.
p	peace, person, peculiar, precious.
r	are, air, hair, her, or, here.
s	his, has, us, sin, sign, such.
t	talk, time, to, unto, train.
w	with, which, woman, was, way, without.
x	example, except, accept, axe.
y	you, your, year, yes.
ch	such, chance, change.
sh	shalt, shall, should.
th	the, thee, they, that.
ious	conscious, judicious.
&c	
viz	

ings, the learner may begin to employ contractions. These admit of much latitude; and being used for his convenience, they may be of his own invention, thereby rendering his own writing legible only to himself, and cutting off the source of all impertinent curiosity. Among the variety that may be adopted, some, or all, of those on plate XVIII, may be found useful and intelligible.

Plate XIII. Represents the *substitute characters,* in which the learner must be very perfect before he proceeds further.

Plate XIV. Contains " A table of the manner of *joining* the *substitute characters*."

Plate XV. Exhibits many approved *contractions and abbreviations,* which may be received, or rejected, or even added to, at the option of the practitioner.

Plate XVI. Furnishes *a lesson,* whereby the learner may the more readily see the force and application of the several rules.

N. B. The letter *r* may be made as usual, when it stands alone; but it is easiest made after the manner exemplified in plate XVII, where *r* and *d* are shewn joined together. In running-hand, *m* may be joined with the *loop* uppermost. In the *plural number, ing* may be made into *ings,* and *tion* and *sion* into *tions* and *sions,* by placing the abbreviating mark *under* the last letter of words, instead of at the end, as in the singular.

Few arts are so useful as the one we are now treating of, or can be compared to it for simplicity both in the invention and execution.

It must not however be concealed that though the art of writing is easily attained, yet the learning to read what we have written is much more difficult, and nothing but much practice will render it at all easy. Young persons who undertake

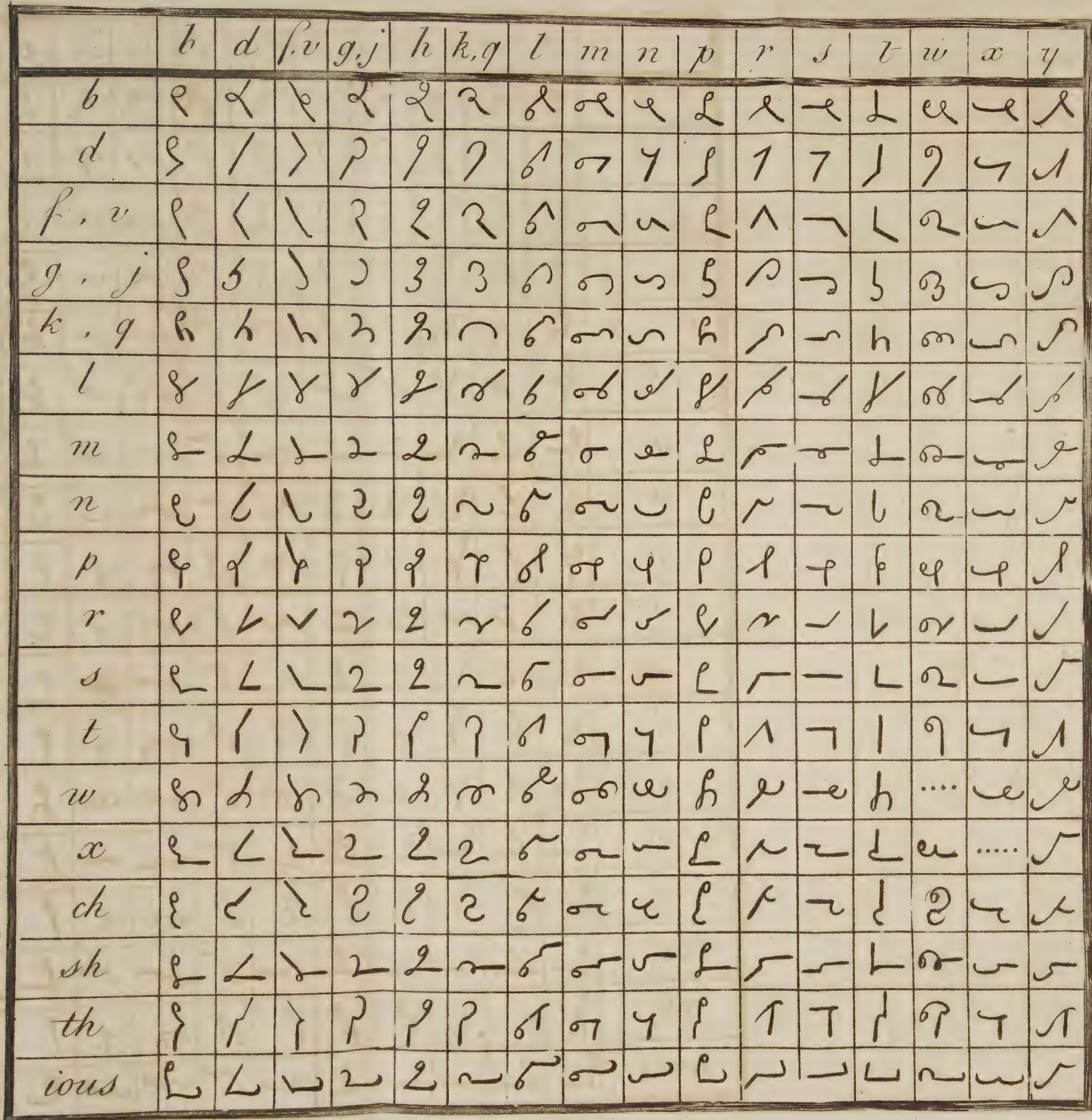
dertake the task must not be discouraged at the difficulties they may meet with: they should every day write something, and on the following day should first read over what they had before committed to paper.

A quick and ready mode of committing either our own thoughts, or those of others, to the safeguard of manuscript, is surely worth all the care we can bestow on it! A thousand thoughts which daily strike us may be preserved from destruction to the probable benefit of ourselves and our posterity; and if the first ideas be crude and undigested, they will have the advantage of time to correct and improve them. They will, moreover, have the valuable property of secrecy, whereby the scrutiny of the critic will be effectually prevented, till mature deliberation shall have fitted them for publication.

But for this elegant and useful accomplishment, the speeches of our best orators would have been long since forgotten, and none but those who had the happiness to be the auditors could ever attain to a knowledge of their excellence.

PART

Pl. XIV. Table of the manner of joining the Characters.



PART XI.

OF SNUFF-MAKING, PAPIER-MACHE, JAPAN-WARE, FLOCK-PAPER.

SNUFF is a powder applied to the internal membrane of the nose, either in a medicinal point of view, or as a pleasurable custom.

It is composed principally of a foreign herb called tobacco, the use of which is too well known to need any description.

Although tobacco is the usual basis of snuff, yet other matters are sometimes added, to give it an agreeable flavour and scent, to suit the peculiar palates and fancies of the several takers. Infinite are the names which the venders of this article have invented; and, perhaps, the succession of days is adding to the catalogue.

It will be sufficient therefore to say, that there are three classes of snuffs, under which all the rest may be placed, viz. 1. *granulated*; 2. an *impalpable powder*; 3. the *bran*, or coarse parts remaining after the second sort has been sifted.

Lord Stanhope has made a calculation of the time wasted by professed snuff-takers, which, as it is both curious and amusing, shall be here inserted.

"Every

"Every professed, inveterate, and incurable snuff-taker," says his Lordship, "at a moderate computation, takes one "pinch in ten minutes. Every pinch, with the agreeable "ceremony of blowing and wiping the nose, and other "incidental circumstances, consumes a minute and a half. "One minute and a half out of every ten, allowing six-"teen hours to a snuff-taking day, amounts to two hours "and twenty-four minutes out of every natural day; or "one day out of every ten. One day out of every ten, "amounts to thirty-six days and a half within the year. "Hence, if we suppose the practice to be persisted in forty "years, two entire years of the snuff-taker's life will be "dedicated to tickling his nose, and two more to blowing "it. The expence of snuff, snuff-boxes, and handker-"chiefs are not here insisted on, though they would make "a separate essay by themselves; in which it might be "made to appear, that this luxury encroaches as much on "the income of the snuff-taker as it does on his time; and "that by a proper application of the time and money thus "lost to the public, a fund might be constituted for the dis-"charge of the national debt."

Whimsical, however, as the above observations undoubtedly are, yet it may be ascertained that the snuff-taker is by no means a useless member of society; for, if the consumption of tobacco be duly estimated, which pays no small duty to the state, and the wear and tear of apparel be added to the accompt, something is rather gained than lost by the public. Nor will the individual snuff-taker be injured; as his Lordship assumes a term of *forty years* to his reckoning, as if life were even prolonged by the operation.

Among all the productions of foreign climes introduced into this kingdom, scarcely any has been held in higher estimation than tobacco. In the countries of which it is a native, it is considered by the Indians as the most valuable offering that can be made to the beings they worship. They use it in all their civil and religious ceremonies. When once the

Abbreviations.

PLATE XV.

~ | N	namely | greatly.	M	monstrous.
~	ment.	n	neither, nothing.
⌣	ious, eous, uous, ius.	n̄	nevertheless.
·	ing, thing.	n̳	nearest, nethermost.
,	tion, sion.	o	over, overhead.
a̲	above, aloft.	o	onwards.
@	around, about.	(r)	round, roundabouts.
a̶	across, athwart.	s—	straight, straightforwards.
a-	afore, aforesaid.	s̳	superior, surplus, supreme.
-a	after, afternoon.	t—	thence, thenceforth.
a	asunder.	(t)	thereabouts.
a-	along.	t	thereon.
ā	amidst, among.	tt	together, twins.
a	alone.	t	topmost, total.
b.-	before, beforehand.	u	utmost, ultimate.
-b	behind.	u	under.
b-	belong.	tt	undermost.
b̄	beneath, below.	u̲	upon, upper.
-b-	between.	u	uppermost, uphill.
p	downwards.	(w)	whereabouts.
d	divide.	w	whereapon, wherein.
e	ere, ear, erenow.	xt	extend, extant.
e—	erelong, early.	y	yonder.
f	forenoon.	z	zenith, zodiac.
f	foremost, furlong.	+	(a full stop)
hi	hither.	⊙	eternity, eternal.
h—	henceforth, hereafter.	1	one.
(h)	hereabouts.	2	two.
h	hereon, hereapon.	3	three.
h	highest.	4	four.
=h	hindermost.	5	five.
i	imprimis, impose.	6	six.
i	infer, inferior, infernal.	7	seven.
-l	latterly, late, lately.	8	eight.
=l	last, lastly.	9	nine.
m̄	medium, midst, middle.	0	(to complete the numbers)
m	middlemost, midmost.	△	life.
m̳	moreover.	∞	death.

A Lesson for Practice.

O come let us sing unto the Lord let us heartily
rejoice in the strength of our salvation. Let us come
before his presence with thanks-giving, and shew ourselves
glad in him with psalms. For the Lord is a great
God and a great King above all Gods. In his hands are
all the corners of the earth, and the strength of the
hills is his also. The sea is his, and he made it, and

the spiral wreaths of its smoke ascend from the feathered pipe of peace, the compact that has been just made, is considered as sacred and inviolable. Likewise, when they address their Great Father, or his guardian spirits, residing, as they believe, in every extraordinary production of nature, they make liberal offerings to them of this valuable plant, not doubting but that they are thus secure of protection.

Tobacco is made up into rolls by the inhabitants of the interior parts of America, by means of a machine called a *tobacco-wheel*. With this machine they spin the leaves, after they are cured, into a twist of any size they think fit; and having folded it into rolls of about twenty pounds each, they lay it by for use. In this state it will keep for several years, and be continually improving, as it always grows milder. The Illinois Indians usually form it into the shape of carrots; which is done by laying a number of leaves on each other, after it has been cured, and the ribs taken out, and then rolling them round with packthread till they become cemented together. The rolls generally measure about eighteen or twenty inches in length, and nine round, in the middle part.

It has been supposed that Sir Walter Raleigh first introduced tobacco into England, about the year 1585, and that he taught his countrymen how to smoke it. Dr. Cotton Mather, however, (in his *Christian Philosopher*) says, that in the above year, one Mr. Lane was the first who brought some over from Virginia to Europe. Considerable quantities of this plant are cultivated in the Levant, on the coasts of Greece and the Archipelago, in Italy, and in the island of Malta. America also annually grows immense quantities, where the plant was discovered by the Spaniards in 1560, and by them regularly imported into Europe. It had been used by the inhabitants of America long before; and was called by those of the islands *yoli*, and by the inhabitants of the continent *pœtum*. Into Spain it went from

Tobaco,

Tobaco, a province of *Yucatan*, where it was originally discovered, and whence its name.

How to reduce Tobacco into Powder.

UNCORD the tobacco, and spread the leaves on a carpet, to dry in the sun. Then pound them in a mortar, and sift through a coarse sieve to get the coarsest powder out of it. As for sifting, you must observe to do it in due proportion as you pound it, and not to pound much at a time. You may also take another method, that of grinding it in one of those small mills which are made on purpose for grinding tobacco. By these means you may, without much trouble, make it as coarse and as fine as you like, by screwing the nut tighter or slacker.

How to purge Snuff, and prepare it for admitting of Odours.

HAVE a small tub pierced with a hole at bottom, which you stop and unstop with a cork as you want it. In this tub put a very thick and close woven cloth, which turn over the rim of the tub, and fix there by the outside. Put your snuff in it, and pour water over it. After it shall have soaked thus twenty-four hours, unstop the hole of the tub and let the water drain away, wringing the cloth in which it is, to help the expression of the water. Repeat this operation three different times, to purge it the better. When this operation is performed, set the snuff to dry in the sun. When dry, put it again in the tub, in the same manner as before, and soak it again, no more with common water, but with some smelling ones, such as for example orange-flower water, *eau-d'ange*, &c. Twenty-four hours after, let the water run off and drain; then set it in the sun

to

to dry as before. In the mean while, stir and mix it again now and then with smelling-water. Such is the indispensible preparation requisite to dispose snuff to receive the odour of flowers. If you do not care to have it so perfectly nice, and should not like to waste so much of it, you may give it but one wash of the common water. This moderate purgation will do pretty well, especially if, while it is a drying in the sun, you knead it the more often in proportion with your fragrant waters, and let it dry each time between.

How to perfume Snuff with Flowers.

The tuberose, the jessamine, the orange flower, are those which communicate the more easily their fragrancy to the snuff. To produce this, have a box lined with white paper, perfectly dry, in which make a bed of snuff of the thickness of an inch; then one of flowers, another of snuff, and anothether of flowers again; continuing so to do, till you have employed all your snuff. After having let this stratification subsist for twenty-four hours, separate the flowers from the snuff, by means of the sieve, and renew the same stratification again, as before, with new flowers. Continue thus to do, till you find that your snuff has acquired a sufficient fragrancy from the flowers: then put it in lead boxes, to keep.

Another Way to do the same.

There are people who make the stratification another way. They inclose their flowers between sheets of white paper filled with pin-holes as thick as possible; this bed they lay between two of snuff; and, as for the small quantity which may have got in the papers through these holes, you sift it out by means of a sheer horse-hair sieve. The flowers must

must be renewed four or five times. This method seems the less troublesome; and the snuff catches the odour nearly as well.

Another Method.

A PREPARATION of snuff may be made of an excessive nice fragrancy with buds of roses. The process is this. Rob those buds of their green cup and the pistillum, which is in the middle; instead of which last, you are skilfully to introduce a clove, without damaging and breaking, or loosening the rose-leaves, which are closely wrapped up one in another. Such buds, thus prepared, put into a glass vessel well covered over with a bladder, and a leather besides, and expose them for a month in the sun; after which term, you make use of these buds as before directed for the other flowers.

Snuff of Mille-fleur.

THIS *mille-fleur* snuff, or snuff of a thousand flowers, is made by mixing together a number of various odorous flowers, managing the quantity of each of them according to the greater or lesser degree of fragrancy they are empowered with, so that none be found to have a predominancy over the others. When that is executed, you proceed, as before directed, to the alternative stratification of this mixture and of the snuff-powder.

Snuff, after the Method practised at Rome.

TAKE the snuff after being perfumed with flowers, and put it in a large bowl, or other proper vessel. Pour over it some white wine, with an addition, if you choose, of essences of musk and amber, or any other such like odours. Then stir

stir your snuff, and rub it all between your hands. In this manner you may have snuff of whatever odour you desire, which, to distinguish from each other, you put into separate lead boxes, with a particular mark.

The Snuff with the Odour of Civet.

TAKE a little civet in your hand with a little snuff; spread that civet, more and more, by bruising with your fingers, and an addition of snuff. After having mixed and remixed i thus in your hand with the whole quantity of snuff, put all again together in its box, as before. You may do the same with respect to other odours.

Amber-Snuff.

As for the amber-snuff, you had better heat the bottom of a mortar, and pound in it twenty grains of amber, adding by degrees one pound of snuff to it, which you handle, rub, and mix afterwards with your hands, to introduce the odour the better among it.

Snuff, Malthese fashion.

TAKE a snuff ready prepared with orange-flower-water (as directed in this chapter, art. 2.) then perfume it with amber as we have just said; after which, with ten grains of civet, which pound with a little sugar in a mortar, you introduce again your snuff by degrees to the quantity of one pound for these ten grains, increasing either the snuff or the odours in the same proportion to each other.

The

The true Malthese Method of preparing Snuff.

TAKE rose-tree and liquorice roots, which you peel. Reduce them into powder, and sift it; then give it what odour you like, adding white wine, brandy, or spirit of wine, and mix your snuff well with this. Such is the true Malthese method of preparing snuff.

The Spanish Method of preparing perfumed Snuff.

1. POUND in a small mortar twenty grains of musk, with a little sugar. Add by degrees as much as one pound of snuff to it: then pound ten grains of civet, and introduce your pound of musked snuff to it, in a gradual manner, as you did before, and rub all together between your hands.

2. The Seville-snuff is the same, with only an addition of twenty grains of vanilla, an ingredient which enters in the composition of chocolate.

3. They who are fond of a milder and sweeter odour in their snuff, may increase the quantity of snuff for the prescribed doses of odours, or diminish the doses of odours prescribed for the quantity of snuff. You must take great care not to let odorous snuff be uncovered in the air, but to keep it very close, for fear it should lose its fragrancy.

4. As the Spanish snuff is excessively fine, and drawing towards a reddish hue, to imitate it in the above prescription, you must chuse fine Holland, well purged, reddened and granulated; pound and sift it through a very fine silk sieve. Then you give it whatever odour you like, after having purged it in the manner we prescribed in this chapter, art. 2.

5. There is no inconveniency in taking a snuff already prepared with flowers, to give it afterwards, when you like an

an odour, musk, amber or other perfume. On the contrary, such a snuff is the readier to take the other odours, and preserve them so much the longer.

To give a Red or Yellow Colour to Snuff.

TAKE the bulk of one or two nuts of red or yellow ochre, with which mix a little white chalk, to temperate the above colours at your pleasure. Grind either of these ochres, with three drachms of oil of almonds; then, continuing to grind it on the stone, add, by little at a time, some water to it, till you see the paste admits of it freely, and becomes very smooth and equal. Now take some gum-tragacanth water, and introduce it likewise to the above paste, stirring and grinding continually, all the while. At last, gather it out of the stone in a large glazed bowl, and dilute it with about one quart of common water, or thereabouts. Then take your snuff, well purged and prepared, as in Art. 2, and throw it in this bowl, wherein handle and rub it well, to make it take the colour more regularly and equally. When it is thus made all into a lump, let it rest twenty-four hours before putting it to dry in the sun, which, immediately after that time, you are to do, spreading it on a dry cloth, and turning it now and then to help its drying the faster. Then you gum it again, by aspersion with gum-tragacanth pulverized and dissolved in some smelling water: or you may again dip your hands into that water, and rub your snuff between your hands thus wetted; which last method is preferable, as it gums the snuff infinitely more regular. Lastly, dry it again in the sun; and, when perfectly dry, sift it through the finest sieve you can find; and then it will be ready to admit of whatever odour you please to impregnate it with.

THE

THE METHOD OF PREPARING AND MOULDING PAPIER MACHE.

Papier Mache is a composition formed of paper, reduced to a pulp by boiling and beating, until it acquires such a consistence as is necessary, with the help of some gummy substance, to receive and retain the figure of the mould in which it is cast. For coarse purposes brown paper is employed, bu for the nicer works writing-paper is necessary. Gum-arabic, glue, and isinglass, are the adhesive substances enerally used, the latter less so, on account of its price.

Mode of preparing the Papier Maché.

Take any quantity of paper, and boil it in water, stirring it about with a wooden spatula, till it becomes of a pasty substance, and appears to have lost its cohesion. Pour off the water from it, and beat it in a mortar, or such kind of machine as will have the same effect, till it assumes a perfectly soft and yielding pulp. Prepare, in the mean time, a strong gum water, by dissolving gum-arabic in water; and having pressed the greatest part of the water out of the pulp, add the gum water to it in such proportion that they may produce together the consistence of a thick fluid. Put them into a proper vessel, and boil them slowly, till they form a paste of the right consistence for casting.

The stiffness of this paste may be varied according to the nature of the work.

Of

Of the Moulds and casting, &c.

The moulds are made either of plaster of Paris, or of wood. For embossed work, or designs of a more complex kind plaster is preferable: but for the simple forms the moulds are best made of wood, which of course is far more durable. The plaster moulds for casting the papier maché must be made in the same manner as those for casting in plaster, and may be the same as practised for plaster. It will be requisite in this instance to grease the moulds extremely well, otherwise there will be a cohesion of the matter and the mould, that will be destructive to both. When any subject is of considerable extension, and one side of it a blank reverse, as in cases of bass reliefs, and other ornaments of that nature, it is usual to lay slips of whole paper, first well moistened with gum-water, or strong size which is rather best in this case. This is a saving and advantage to the work, as it adds greatly to the strength and tenacity, and more particularly preserves it, during the time of its drying. Wooden moulds are employed for forming cups, boxes, or flat pieces of any kind, where there is no embossed work. These are best made of box, or other hard wood, turned into the proper figure; and, in order to let out the fluid in the concave parts of the mould, near the middle, should be made three or four small holes. The moulds, when used, should be first well greased, and placed before a fire, that they may imbibe as much grease as possible, which will render the oiling afterwards more effectual. When the moulds are prepared, the surface of the concave or hollow part must be spread over with paste as even as possible, about the thickness of the hollow between the two parts; the cover of the mould is next placed over, and compressed till it is in its proper place. The cast is suffered to remain in the mould until it acquires a sufficient strength by

drying to maintain its shape when taken out. The cast is finally freed from the mould and dried; which is varnished, or painted, as may be thought most fit.

The Method of moulding Whole Paper for forming Snuff-boxes.

THE whole paper is moulded nearly in the same manner as papier maché: but can only be employed for such pieces as have a flat surface. Paper of the strongest brown kind, with an even texture, is necessary for this purpose; and all lumps and inequalities should be removed. When cut into pieces the size requisite according to the form of the mould, it should be moistened with gum-water, till it is pliable, and moderately soft, sufficient to adapt it to the mould. The mould should next be oiled, the pieces laid on the convex or solid part, and each piece brushed over with a thin paste, made by boiling flour and water together for some time, to which is added one pound two ounces of common size. These slips should be increased, till the proper thickness required is produced. The hollow mould is then placed over them, and sufficient pressure employed, till each piece has regained its place. When the cast is hard enough it is removed and dried. Snuff-boxes are made in two parts, and such other pieces as have jointed lids. Cups and boxes formed in this manner should always be well coated with a good varnish.

Mode of preparing a Composition for light Japan Ware.

TAKE saw-dust of fir-wood, and sift off, by the use of two sieves of different fineness, all the most gross part and the smallest. Melt equal parts of rosin and turpentine, with a half part of bees-wax, and put into the melted mix-

 ture

ture as much of the saw-dust as can be added without rendering the mass of a thicker consistence than can bear to be poured. Stir the saw-dust and melted matter together till they are well mixed, and then cast them into proper moulds. If it be desired to render the matter harder, a little shell-lac or gum-sarcocol may be added, in powder, to the mixture, but this should not be done before the saw-dust be well united with the other ingredients; and the matter should be kept no longer in the fire afterwards, than may be necessary for melting and mixing the shell-lac or gum with the rest. The whole of this mixture should be used at one time, for it cannot be brought to a proper state for casting, by being re-heated, without damaging it by burning. This composition is not superior to the papier maché, or the whole paper, for making snuff-boxes, &c.

The Mode of preparing coloured or marble Paper.

The apparatus necessary for this purpose is a trough for containing gum-tragacanth, and the different colours that are used; a comb or quill for disposing them in the figure usually chosen, and a burnishing stone for polishing the paper. The trough is made of any description of wood, somewhat larger than the sheets of paper intended to be marbled, and the sides to rise only two inches above the bottom; for by these means a lesser quantity of gum is used. The comb may be also made of wood, five inches in length, with brass teeth about too inches long, and placed about two inches from each other. The burnishing stone may be made of jasper or agate. When thus equipped, prepare a solution of gum-tragacanth, by putting some of the clear and white gum into a little water, and letting it remain three or four days till it is dissolved. This solution should be as strong as gum-water used in miniature painting. It is next strained, and put into the trough. Red lead, vermil-

 lion,

lion, rose-pink, lake, and carmine, are employed, the two first are too hard and glaring, unless they are brought to a softer cast by rose pink or lake, but for common purposes the latter colours are too dear, for blue verditer and Prussian blue; for yellow, Dutch pink and yellow ochre; for green, a mixture of Dutch pink and Prussian blue, or verdigrise; for orange, orange lake, or a mixture of vermillion, with Dutch pink; for purple, rose pink and Prussian blue.

The colours are to be ground fine, with spirits of wine; and at the same time of using them a little fish-gall, or gall of a beast, should be added by grinding them again with it. The proportion of the gall must be found by trying them, which will be known by the spots joining together, when sprinkled on the gum-tragacanth, without intermixing. Being thus prepared, the mode of proceeding is as follows: Pour the solution of the gum-tragacanth into the trough, and the colours being in separate pots, with a pencil to each, sprinkle on the surface of the solution, by shaking the pencil charged with its proper colour, over it; this is generally done with different colours, till the whole surface is covered. Where whorls or snail-shell figures are wanted, they must be made by means of a goose-quill. The waving jagged lengths are done by the comb before described, which is passed through the colours from one end of the trough to the other. The paper is previously prepared by dipping it over-night in water, for receiving the colours, as is practised in copper-plate printing, &c. The paper must be held by two corners, and laid in the most gentle and even manner on the solution covered with the colours, and softly pressed with the hand, that it may bear every where on the solution. It must be next raised and taken off, with the same care, and hung across a cord to dry. The last operation is the polishing, which is performed by rubbing the paper with soap, and afterwards polishing it with a calender glass, such as is used for linen. Finally, to render the polish still higher, it is rubbed with burnished jasper or agate.

Mode

Mode of preparing Flock Paper.

The paper designed for receiving flock is first prepared with a varnish ground, for the usual ground would not allow of its adhering strongly to the paper, of which we have already given an account of in calico-printing, &c. Therefore the ground used is varnish, with some proper colour, according to the flock employed. Instead of the oil of turpentine varnish, a composition of drying oil and resin, to which some gum-sandarac may be added, might be used with advantage. But for light colours the brownness of this mixture might be injurious, and as it would dry slower would be somewhat incommodious. Flock is generally laid on either by means of a print or stencil. But as detached parts only are executed by the stencil, it is extremely confined, and the print therefore is most generally preferred. The method of laying on the flock by means of a print is this: A wooden print being cut, as is described for laying impressions on paper, prints, &c. (Vide Cutting on Wood, Vol. II.) Some varnish is put on a block, covered with leather or oil-cloth, in the same way as is there directed for colours in calico-printing, the stamp is then pressed on this varnished block, and placed on the paper with a little force. The sheet thus prepared by the varnished impression, is now removed to another block or table, and strewed over with the flock, which is afterwards gently compressed by a board, or some other flat body, to make the varnish take the better hold of it. The sheet is next hung in a frame till the varnish is perfectly dry, at which time the superfluous flock is brushed off by a soft camel's-hair brush; and the proper flock will be found to adhere in a very strong manner. When the stencil is used, the same method is to be pursued; the varnish for holding the flock being laid on by that, instead of a print; and the flock afterwards strewed upon it, as in the

the other case. The usual method of preparing the flock is by cutting the woollen rags or pieces of cloth with the hand, by means of a large bill or chopping-knife. But it is better done by a machine. In such cases the construction of that part of the machine, which is made for the cutting the flock, is this: A box is made for containing the rags to be cut, which is open at the top, and of such size as may best suit the quantity of rags that the force employed can cut. A blade is also to be made, the length of which is to be equal to the breadth of the box; and it should be strong, and must be charged with a great weight, and raised with a quick motion. The box, being filled with the rags, is placed under the knife, and made to move by nitches, after the stroke of the blade is given, just so far as where it is proper the blade should again cut the cloth or rags, while, at the same time, the blade is lifted up, and let fall on the cloth, which it cuts through, till by successive strokes, and the progressive motion of the box under it, the whole quantity of cloth or rags in the box have been cut.

METHOD OF ORNAMENTING AND EMBOSSING WOOD.

To adorn Wood with Ornaments of Silver or Tin.

First carve, or hollow, your ornaments out upon your wood, in the best manner, so as to undermine the edges on both sides of your strokes. Then make an amalgam of tin, by dissolving it over a gentle heat, and putting into it the same quantity of quicksilver, which you have heated; stir with a stick well together, and pour it into a pan of cold

cold water; when dry, grind it upon a marble, with water, very fine, tempering it with clear size; then fill up the carved figures, smoothing it with your hand; and, when dry, polish it. To make it more of a silver colour, rub it over with an amalgam of silver-leaf and quicksilver, and polish it with a dog's tooth.

Instead of tin, you may use bismuth ground fine with water.

To Emboss, or trace different Ornaments on a gilded smooth Pannel, the Gold being laid over with Black, or any other Colour.

First gild your pannel, or other wood work, as you are directed under the article of gilding, and when thoroughly dry, paint it all over smooth and even with lamp-black, ground with linseed and nut oil: add to it an equal quantity of umber, in order to dry it the better; after you have set it for two or three days, or more, according to the time of the year, to dry, then, before it is quite hard, draw or pounce what you design to emboss, and with a blunt-pointed bodkin, horn, or wood, trace into the black lay, down to the gold, opening the traces, and making the gold appear in the best manner you can. In birds, plants, cattle, and such like, you must observe to take the heightenings clear out, and leave the shade, by hatching into the black, agreeable to your design; the fine and soft shades of the hair, &c. you may finish with a fine pencil, with the black colour, upon the gold; and when you have done, let it dry thoroughly for three or four days more; then lay over it a clear varnish, which you may, after it is dried, repeat a second time, and your work will look beautiful.

To do this upon a Blue Ground.

AFTER you have gilded your work, then take alum which is not too coarse, mix it with mortar on a marble-stone, adding to it the white of an egg: with this and a little water mix your smalt, and strike it fine and even over the gilding: then, when it is almost dry, sift through a fine sieve some of the finest smalt over it: you may, if you will, mix it with spangles of several colours; and when thoroughly dry, wipe off what sticks not to it, and proceed in tracing up your figures you design for gold. The fine finishing strokes upon the gold, because they cannot well be done with smalt, may be done with Prussian blue or indigo mixed with white lead. You may, if you will, varnish it; but it will look better without.

PART XII.

OF WRITING INKS:

METHOD OF REMOVING STAINS OF INK, WINE, GREASE, &c.—CEMENTS, GLUES, SIZE, &c.

Writing Ink.

TAKE of Aleppo galls, in coarse powder, eight ounces; of logwood, in thin chips, four ounces; sulphate of iron (green copperas) four ounces; powdered gum-arabic, three ounces; sulphate of copper (blue vitriol) and sugar-candy, of each one ounce. Boil the galls and logwood together in twelve pints of water for one hour, or till half the liquid has been evaporated. Let the decoction be strained through a hair sieve, or linen cloth: the rest of the ingredients are then to be added. Stir the mixture till the whole is dissolved, more especially the gum; after which, leave it to subside for twenty-four hours. Decant the ink, and preserve it in bottles well corked.

Red

Red Writing Ink.

Take of the raspings of brazil wood, four ounces; best vinegar, one pint; powdered alum, half an ounce: these should be mixed, and the ink suffered to remain upon the ingredients till it has acquired a colour sufficiently deep. If required very deep, it may be boiled for an hour over a gentle fire.

Blue Ink.

Take elder-berries, and press out the juice into a glass, and put powdered alum to it; add to it about its fourth part of vinegar, and a little urine; then dip a rag into it, and try whether the colour is to your liking: if it is too pale, add a little more of the juice; and if too dark, add more vinegar to it.

Printing Ink.

Printers' ink is a black paint composed of lamp-black and linseed, or sweet oil, boiled, so as to acquire considerable consistence and tenacity. The art of preparing it is kept a secret; but the obtaining good lamp-black appears to be the chief difficulty in making it.

The ink used by copper-plate printers differs from the last only in the oil not being so much boiled, and the black which is used being Frankfort-black.

Sympathetic Inks.

Such inks as do not appear after they are written with, but which may be made to appear at pleasure, are termed sympathetic

sympathetic inks. For this purpose a variety of substances have been used, some of which we shall here describe.

1. Dissolve some sugar of lead in water, and write with the solution. When dry, no writing will appear; but when you want it visible, wet the paper with a solution of alkaline sulphuret (liver of sulphur), and the letters will immediately appear of a brown colour. Even exposing the writing to the vapours of these solutions will render it apparent.

2. Write with a solution of gold in aqua-regia, and let the paper dry gently in the shade. When you wish the letters to appear, draw a sponge over them wetted with a solution of tin in aqua-regia, the writing will immediately appear of a purple colour.

3. Make use of an infusion of galls, and when dry, dip it into a solution of sulphate of iron (copperas), which will make the writing appear black.

4. If any letter be written with sulphuric acid, when it is held to the fire, the letters will appear black.

5. The same may be produced with a solution of sal-ammoniac, the juice of lemons or onions; but the letters will not appear so readily by the application of heat.

6. Make a solution of cobalt in nitro-muriatic acid (aqua-regia), with this solution write. When the paper is held to the fire the letters will appear green, and will disappear when cold.

Thus they may be made to appear and disappear at pleasure. A winter scene may be so drawn, and the leaves of the trees be drawn with this ink; and by holding it near the fire be made to look like the verdure of spring.

7. Blue sympathetic ink. Dissolve cobalt in nitric; precipitate the cobalt by potash; dissolve this precipitated oxyde of cobalt in acetic acid, and add to the solution one eighth of common salt. This will form a sympathetic ink, that when cold, will be invisible, and by heat will appear blue.

REMOVAL

REMOVAL OF STAINS.

Ink Stains.

THE stains of ink in cloth, paper, or wood, may be removed by almost all acids; but those acids are to be preferred which are least likely to injure the texture of the stained substance. The muriatic-acid, or spirits of salts, diluted with five or six times its weight of water, may be applied to the spot, and after a minute or two may be washed off, repeating its application as often as may be found necessary. But the vegetable acids are attended with less risk, and are equally effectual. A solution of the oxalic, citric, (lemon juice), or tartareous acids, in water, may be applied to the most delicate fabric without any danger of injuring them; and the same solutions discharge from paper, written, but not printed ink. Hence they may be employed in cleaning books, which have been defaced by writing on the margin, without impairing the text.

Iron Stains.

THESE may be occasioned either by ink stains, which, on the application of soap, are changed into iron stains, or by the direct contact of rusted iron. They may be removed by diluted muriatic-acid, or by one of the vegetable acids already mentioned. When suffered to remain long on cloth, they become extremely difficult to take out; because the iron, by moistening with water, and exposure to the air, requires such an addition of oxygen as renders it insoluble in acids. These spots, however, may be discharged, by applying first a solution of an alkaline sulphuret, which must be well washed from

from the cloth, and afterwards a liquid acid. The sulphuret in this case extracts part of the oxygen from the iron, and renders it soluble in acids.

Fruit and Wine Stains.

THESE are best removed by a watery solution of oxy-muriatic acid, or by the oxy-muriatic of lime, to which a little sulphuric acid has been added. The stained spot may be steeped in one of these solutions till it is discharged; but the solution can only be applied with safety to white goods, because the uncombined oxy-muriatic acid discharges all the printed dyed colours. A convenient method of applying oxy-muriatic acid, easily practicable by persons who have not the apparatus for saturating water with gas, is as follows: Put about a table-spoonful of muriatic-acid (spirits of salt) into a tea-cup, and add to it about a tea-spoonful of manganese in powder. Set this in a larger one filled with hot water; moisten the stained spot with water, and expose it to the fumes that arise from the tea-cup. If the exposure be continued a sufficient length of time, the stain will disappear. Stains on silk may be removed by a watery solution of sulphuric acid (vitriolic acid), or by the fumes of burning sulphur.

Spots of Grease.

THESE may be removed by a diluted solution of pure potash; but this must be cautiously applied, to prevent injury to the cloth. *Stains of white wax,* which sometimes fall upon the clothes from wax candles, are removable by spirit of turpentine, or sulphuric ether. *The marks of white paint* may also be discharged by the last mentioned agents, or by spirit of wine.

A Method

A Method of removing Spots of Grease out of Books, Prints, or Paper.

After having gently warmed the paper that is stained with grease, wax, oil, or any other fat body, take out as much as possible of it by means of blotting paper, which must be carefully kept warm. This operation must be repeated as many times as the quantity of the fat body imbibed by the paper, or the thickness of the paper, may render necessary. When the greasy substance is entirely removed, recourse may be had to the following method to restore the paper to its former whiteness, which is not completed by the first process. Dip another brush in highly rectified spirit of wine, and draw it in like manner over the place which was stained, and particularly round the edges, to remove the border that would still present a stain. By employing these means with proper caution, the spot will totally disappear, the paper will resume its original whiteness; and if the process has been employed on a part written on with common ink, or printed with printer's ink, it will experience no alteration.

OF CEMENTS.

Cements are made of various substances, according to the bodies to which they are applied, and are different when exposed to moisture and heat.

Common

Common Glue.

GLUE is manufactured in the large way from the shreds and parings of skins, leather, and sometimes from the bones of animals. Tanned leather does not yield glue, because that the jelly is there combined with tanning. This is a substance too well known to need description, and can be bought much cheaper than can be made good upon a small scale. The best kind is made in England in square pieces of a ruddy brown colour, and next to this is the Flander's glue.

Isinglass Glue.

THIS glue is made by dissolving isinglass in water, by boiling and having strained it through a coarse linen cloth, evaporating it again to such a consistence, that when cold the glue shall be perfectly hard and dry.

This cement is improved by dissolving the isinglass in any proof spirit by heat, or by adding to it, when dissolved in water, an equal quantity of spirits of wine.

This forms a useful glue, and is far preferable for nice purposes to common glue: being much stronger, and less liable to be softened either by heat or moisture.

Parchment Glue.

BOIL in six quarts of water one pound of shreds of parchment, or vellum, till the quantity be reduced to one quart. Strain off the fluid from the dregs, and then boil it again till it be of the consistence of glue.

The same may be done with glover's cuttings of leather, which are dressed instead of being tanned; this forms a colourless glue.

Glues

Glues that will resist Moisture.

WHEN glues are required for sign boards, and placed in such situations as are exposed to the weather, the following will be found to answer the purpose. Melt common glue with water to a proper consistence; add one eighth of boiled linseed oil, dropping it into the glue gently, and stirring it all the time. This glue may be rendered stronger by the addition of some powdered chalk. A good glue may be made for the same purpose, by adding half a pound of common glue to two quarts of skimmed milk.

Lip Glue for cementing Silk, thin Leather, Paper, &c.

TAKE of isinglass and parchment glue, of each one ounce; sugar-candy and gum-tragacanth, of each two drachms; water, one ounce. Boil the whole together till the mixture appears, when cold, of the proper consistence of glue; which form into rolls of any convenient size. This glue need only be wetted with the tongue, and rubbed on the edges of the paper; and when dry will be found to unite firmly.

Jeweller's Cement.

SOMETIMES in setting precious stones pieces are broken off by accident. In such cases, they often join the pieces so correctly, that those only who are experienced in this art can discover it. For this purpose a piece of gum-mastick is employed, which is placed between the fragments, which are previously heated, so that the interposed gum is dissolved by them, and the redundant gum is forced out by pressing them firmly together.

A Cement

A Cement for joining broken Glass.

Beat the white of an egg very clear, old thick varnish, and mix with it powdered quick lime; with this join your broken glasses, china, and earthen ware. *Or,*

Take isinglass, powdered chalk, and a little lime; mix them together, and dissolve in fair water over a slow fire; with which cement your broken glass, or china ware, and set it to dry in the shade. *Or,*

Take isinglass, mastich, and turpentine; dissolve them, and cement your broken ware; when dry, they will hold, and rather break in another place, than where joined and cemented. *Or,*

Take quick-lime, and mix it with old cheese which has been boiled in water to a paste; with this cement your glass, or china, and it will answer your desire. This paste is likewise a good *lute*, to lute a cover to an earthen pan, or glass, retorts, &c. You may add a little fine brick-dust to it.

A Lute or Cement, for Cracks in Glasses used for Chemical Preparations, which will stand the Fire.

Take wheat-flour, finely powdered Venice glass, or Florence flask, pulverized chalk, of each an equal quantity; fine brick-dust one half of the quantity, and a little scraped lint; mix it up with the white of an egg, smear it on a linen cloth like a plaister, and with it enclose the cracks of your glass retort, or other glass utensil; but let it dry before you put it to the fire. *Or,*

Take old varnish, and glue your pieces together; tie them close, and set them to dry in the sun, or a warm place; when dry, scrape off the varnish that is pressed out at the sides, and it will hold very well.

To join broken Amber.

Anoint the pieces with linseed oil, join and hold them close together over the fire.

An excellent Glue or Cement to mix with Stone, Glass, Marble, &c. in order to make Utensils, Images, and other things therewith.

Take of fine glue four ounces; of mastich two ounces; of powdered sealing-wax six ounces; of finely ground brick-dust one ounce; put the fish glue into a glazed pipkin, with water, upon a slow fire; and after you have mixed your ingredients, put it into the pipkin, and boil it up; and what hangs together, use; if you mix it up with finely powdered glass, of any colour, you may form it to what shape you will; and when cold and dry, it will be as hard as stone.

Another Cement, which dries quickly.

Take pitch, as much as you will; melt it, and mix it with brick-dust and litharge; and, to make it harder, moisten the brick-dust first with sharp vinegar and a larger quantity of the litharge, and it will be as hard as stone.

A Cement useful for Turners.

Take of resin, one pound; pitch, four ounces: melt these together, and add, while hot, a quantity of brick-dust, sufficient to make it hard when cool. Make it up into rolls of a convenient size.

Another,

Another, finer.

TAKE of resin one ounce; pitch, two ounces: to which add, of red ochre, a sufficient quantity to make it strongly adhesive.

A strong Cement for Electrical Purposes, &c.

TAKE of resin one pound; which melt slowly over the fire; and add to it as much plaster of Paris as will make it sufficiently hard; then add a spoonful of linseed oil, stirring it constantly: next try if it be tough enough for the purpose required; if it is not sufficiently hard, add more plaster of Paris; and if not tough enough, a little more linseed oil.

This cement answers the purpose well for fixing the necks of globes, or cylinders, or any thing else that require to be strongly fixed; for it is not easily melted when cold.

To Solder or Cement broken Glass.

BROKEN glass may be soldered or cemented in such a manner as to be as strong as ever, by interposing between the parts, glass ground up like a pigment, but of easier fusion than the pieces to be joined, and then exposing them to such a heat as will fuse the cementing ingredient, and make the pieces agglutinate without being themselves fused.

A glass for the purpose of cementing broken pieces of flint glass, may be made by fusing some of the same kind of glass, previously reduced to powder, along with a little red-lead and borax, or with the borax only.

Cement for Derbyshire Spar, or other Stones.

Take about seven or eight parts of resin, and one of bees-wax: melt them together with a small quantity of the plaster of Paris. When it is wished that this cement should likewise fill up any vacancies that there may be, a little more plaster is then added. Melted sulphur interposed between the broken fragments, forms a pretty durable cement.

A Cement that will stand against boiling Water, and bear.

In joining the flanches of iron cylinders, and other parts of hydraulic and steam engines, great inconvenience is often experienced from the want of a durable cement. Boiled linseed oil, litharge, red and white lead, mixed together to a proper consistence, and applied on each side of a piece of flannel, previously shaped to fit the joint, and then interposed between the pieces before they are brought home to their place by the screws, &c. employed as fastenings, make a durable cement. The proportions of these ingredients may be varied, according to circumstances. This cement answers well for joining broken stones, however large, if a small quantity of white lead be added. Cisterns built of square stones, put together with this cement, will never leak.

Another Cement for this Purpose may be made in the following Manner.

Take of sal-ammoniac (muriate of Ammonia) one ounce; flowers of sulphur one ounce; iron filings 16 ounces. Mix these well by rubbing them in a mortar, and keep them dry. When wanted for use, take one part of the above powder, and

and 20 parts of clean iron filings, and blend them intimately by grinding them in a mortar. Wet the compound with water, and when brought to a convenient consistence, apply it to the joints with a wooden or blunt-iron spatula.

Blood Cement.

COPPER-SMITHS lay over the rivets and edges of the sheets of copper in large boilers, a cement, to serve the additional security to the joinings, and to secure cocks, &c. from leaking: this is made by mixing pounded quick-lime with ox's blood. It must be applied fresh made, as it soon gets hard. If the properties of this were duly investigated, it would be found useful for many purposes to which it has never yet been applied. It is extremely cheap, and very durable.

Flour Paste.

FLOUR-PASTE, for cementing, is formed principally of wheaten flour, boiled in water till it is of a glutinous and viscid consistence. It may be prepared from these ingredients simply for common purposes; but when it is used by book-binders or paper-hangers, it is usual to mix with the flour one-fifth of its weight of powdered alum: and when it is wanted still more tenacious, gum-arabic, or any kind of size, may be added.

Japanese Cement, or Rice Glue.

THIS cement is made by mixing rice-flour intimately with water, and then gently boiling it. It is beautifully white, and dries almost transparent. Papers pasted together by means of this cement will sooner separate in their own substance

than

than at the joining, which makes it extremely useful in the preparation of curious paper articles, as tea-trays, ladies' dressing-cases, and other articles, which require layers of paper to be cemented together. It is in every respect preferable to common paste made with wheat flour, for almost every purpose to which that article is usually applied. It answers well in particular for pasting into books the copies of writings taken off by copying machines. With this composition, made with a small quantity of water, that it may have a consistence similar to plastic clay, models, busts, statues, bases, relievos, and the like, may be formed. When dry, the articles are susceptible of a high polish; and are also very durable.

PART

PART XIII.

CHEMICAL ACTION:

CHEMICAL AND OTHER MISCELLANEOUS EXPERIMENTS.

WE shall, as a conclusion to the present volume, give a brief account of Chemical attraction, with a variety of experiments that may prove useful as well in the way of amusement as instruction. We trust, the application of the several articles contained in this part will be of practical importance to many persons who have not access to Rose books in * which the topics are discussed more at large. All bodies have a reciprocal action on each other, which produces modifications in their forms, or changes in their nature and constitution. The means, cause, and result of which the natural philosopher and chemist are solicitous to discover. The former ascertains the action of the properties of such bodies as can be ascertained without altering their nature; such

* The reader may be referred, for all the information he can possibly require, to Fourcroy's Philosophy of Chemistry, by Desmoud; Henry's Epitome; Murray's and Thomson's Complete Systems; and Aikin's Chemical Dictionary,

as gravity, elasticity, temperature, motion, &c. The latter studies the more immediate action of bodies, and particularly notices the phenomena which change their nature and constitution. Chemical action embraces all the phenomena which exhibit combinations and decompositions, and thus the operations of nature or of art, which occasion changes in the nature of bodies, fall within the province of chemistry: it accordingly embraces in its studies all the phenomena which nature presents to our view in the vast variety of her productions, and all the processes of the arts for which we are indebted to human ingenuity.

All the facts and experiments in chemistry may be referred to the following phenomena, viz.

1. The action of light on bodies.
2. The action of heat on bodies.
3. The action of air in combustion.
4. The nature and action of water.
5. The nature and action of earths, and the formation of alkalies, with their actions in combinations.
6. The nature and properties of combustible bodies.
7. The formation and decomposition of acids.
8. The union of acids with earths and alkalies.
9. The oxydation and dissolution of metals.
10. The nature and formation of vegetable substances.
11. The transition of vegetables to a state of animal matter, and the nature of the latter.
12. The spontaneous decomposition of animal and vegetable substances.

By the term affinity, the chemist expresses the chemical action which bodies mutually exercise on each other, when they are at imperceptible distances: it is therefore the basis and regulator of all chemical operations.

The following very simple experiments will shew the nature of chemical affinity better than any reasoning on the subject. For these scarcely any apparatus is necessary, ex-

cepting

cepting what is to be found in almost every house, to which our volumes will have access.

Some Bodies have no affinity for each other.

EXAMPLE 1. Oil and water, or mercury and water, when shaken together, do not combine, the oil always rising to the surface, and the mercury sinking to the bottom.

Examples of Solution.

Ex. 2. Sugar or common salt in water; chalk in dilute muriatic acid.

Influence of Mechanical Division in promoting the Action of Chemical Affinity, or in favouring Solution.

Ex. 3. Lumps of chalk or marble in dilute muriatic acid, compared with the same bodies in powder. In the common arts of life, the rasping or grinding of wood and other substances, are familiar examples.

Hot Liquids are more powerful Solvents than cold ones.

Ex. 4. Cold water, after having taken up as much as it can of sulphate of soda, will dissolve still more when heated; and the portion, which has been dissolved in consequence of applying heat, will separate again, in a regular form, when the liquor cools. This last appearance affords an instance of *crystallization.*

A very

A very minute Division of Bodies is effected by Solution.

Ex. 5. Dissolve two grains of sulphate of iron in a quart of water, and add a few drops of this solution to a wine glass full of water, into which a few drops of tincture of galls have been poured. The dilute infusion of galls will speedily assume a purplish hue. This shews that every drop of the quart of water, in which the sulphate of iron was dissolved, contains a notable portion of the salt.

Some Bodies dissolve much more readily and copiously than others.

Ex. 6. Thus an ounce measure of distilled water will dissolve one third of its weight of sulphate of soda; one sixteenth of sulphate of potash; and only one five hundredth of its weight of sulphate of lime.

Mechanical Agitation facilitates Solution.

Ex. 7. Into a wine-glass full of water, tinged blue with the infusion of litmus, let fall a small lump of solid tartarous acid. The acid, if left at rest, even during some hours, will only change to red that portion of the infusion, which is in immediate contact with it. Stir the liquor, and the whole will immediately become red.

Bodies do not act on each other, unless either one or both be in a State of Solution.

Ex. 8. Mix some dry acid of tartar with dry carbonate of potash. No combination will ensue till water is added, which

which acting the part of a solvent promotes the union of the acid and alkali, as appears from the violent effervescence.

Spread thinly on a piece of tin-foil, three or four inches square, some dry nitrate of copper, and wrap it up. No effect will follow. Unfold the tin-foil, and having sprinkled the nitrate of copper with very little water, wrap it up again as quickly as possible, pressing down the edges closely. Considerable heat, attended with fumes, will now be excited; and if the experiment has been dexterously managed, even light will be evolved. This shews that nitrate of copper has no action on tin, till in a state of solution.

Two Bodies, having no affinity for each other, unite by the Intervention of a third.

Ex. 9. The oil and water, which in expt. 1st. conld not, by agitation, be brought into union, unite intimately by adding a little caustic potash. The alkali, in this case, acts as an intermedium.

Saturation illustrated.

Ex. 10. Water, after having taken up as much common salt as it can dissolve, is said to be saturated with salt. Muriatic acid, when it has ceased to act any longer on lime, is said to be saturated.

The Properties, characterizing Bodies when separate, are destroyed, by Chemical Combination.

Ex. 11. Thus muriatic acid and lime, which, in a separate state, have each a most corrosive taste, lose this en-

 tirely,

tirely, when mutually saturated; the compound is extremely soluble, though lime itself is very difficult of solution; the acid no longer reddens vegetable blue colours; nor does the lime change them, as before, to green.

Simple elective Affinity illustrated.

Ex. 12. Add to the combination of oil with alkali, formed in expt. 9th. a little dilute sulphuric acid. The acid will seize the alkali, and set the oil at liberty, which will rise to the top. In this instance, the affinity of alkali for acid is greater than that of alkali for oil. To a dilute solution of muriate of lime, add a little of the solution of pure potash. The potash will seize the muriatic acid, and the lime will fall down, or be *precipitated.*

Double elective Affinity exemplified.

Ex. 13. In a watery solution of sulphate of zinc, immerse a thin sheet of lead. The lead will remain unaltered, as will, also, the sulphate of zinc; because zinc attracts sulphuric acid more strongly than lead. But let acetite of lead be mixed with sulphate of zinc; the lead will then go over to the sulphuric acid, while the zinc passes to the acetous. The sulphate of lead, being insoluble, will fall down in the state of a white powder; but the acetite of zinc will remain in solution.

We shall now give a list of chemical preparations, for performing many experiments, with references, so as to render the operations extremely easy.

1. Sul-

1. Sulphuric acid.
2. Fixed alkali dissolved.
*2. Dry fixed alkali.
3. Volatile alkali.
4. Syrup of violets.
5. Copper in sulphuric acid.
6. Epsom salts in water.
7. Tincture of galls.
8. Iron in sulphuric acid.
9. Silver in nitreous acid.
10. Quicksilver in nitric acid.
11. Lead in nitric acid.
12. Copper in nitric acid.
13. Invisible ink.
14. Marking ink.
15. Washing ink.
16. Green ink.
17. Phlogisticated alkali *.
18. Phosphoric ether.
19. Solution for firing tin.
20. Solid phosphorus.
21. Sal-ammoniac.
22. Spirit of wine.
23. Solution of soap.
24. Blue liquid dye.
25. Liquor of flints.

Directions for making the Experiments.

EXPERIMENT I.—To three or four tea-spoonfuls of the fixed alkali, No. 2, in a wine glass, add by little at a time some of No. 1, an ebullition will arise; the fixed air escap-

* The alkali, saturated with the colouring matter of Prussian blue, formerly received the name of phlogisticated alkali.

ing,

ing, particles of salt will be forced up with it, and resemble a fountain: keep adding by degrees of No. 1, till no more ebullition is excited, and great part of the liquid will be converted into a salt.

Ex. 2.—Two or three tea-spoonfuls of No. 3, in a wine glass, will smell very pungent; if you add to it No. 1, and stir it with a small stick, the smell will be taken away; and by adding some of No. 2 to the mixture, it will become pungent again.

Ex. 3 and 4.—Put half a table-spoonful of No. 4, and three table-spoonfuls of water into a glass, and stir them well together with a stick, and put half of the mixture into another glass. If you add a few drops of No. 1 into one of the glasses, and stir it, it will be changed into a crimson; and a few drops of No. 2 into the other glass, it will change it green, upon stirring it. If you drop slowly into the green colour from the side of the glass a few drops of No. 1, you will perceive crimson at the bottom, purple in the middle, and green on the upper surface; and by adding a little of No. 2 to the other glass, the same colours will appear in different order.

Ex. 5 and 6.—If you put a tea-spoonful of No. 5 into a glass, and add two or three table-spoonfuls of water to it, there will be no sensible colour produced; but if you add a little of No. 3 to it, and stir it, you will perceive a very beautiful blue colour; upon adding a little of No. 1, the colour will instantly disappear upon stirring it; and by adding a little of No. 2, will return again.

Ex. 7 and 8.—Put a tea-spoonful of No. 6 into half a glass of water, and stir it; add gradually a little of No. 2, and a white precipitate will fall down, which is magnesia; then add gradually of No. 1, stir it, and the liquor will become transparent.

Ex. 9 and 10.—Put a tea-spoonful of No. 7 into half a glass of water, and drop into it a little of No. 8, and a black colour will be produced; add a little of No. 1, and the colour

lour will be destroyed, and by adding some of No. 2, be restored again. In all these experiments, stirring with a stick, or piece of a match, is necessary.

Ex. 11.—Put three or four tea spoonfuls of No. 6 into a glass, and add gradually of No. 2, and stir it; a white solid body will be produced from the two liquids; this solid body may be converted again into a liquid, by adding copiously of No. 1.

Ex. 12.—Mix equal parts of No. 6 and No. 22 together, and stir them well; let the mixture stand for a minute or two, and a solid body of crystallized salt will be produced. In the winter, the solid salt is produced instantly by shaking them together; but to make it act instantaneously, the solution, No. 6, should be fresh made.

Ex. 13.—Put half a tea-spoonful of No. 8 into half a glass of water; by adding a few drops of No. 17, a Prussian blue will be precipitated.

Ex. 14, is made with the phosphoric ether, No. 18 to be used according to the following directions. Wet a lump of sugar about the size of a large nutmeg, and put it into a bowl or bason of water, stirring it about a little with your finger, when there will instantly appear a pleasing illumination, which, by blowing on it, will cause curious variations. The water should be quite cold.

Ex. 15, is made with the solid phosphorus, No. 20.

To produce beautiful Fire-Works in Miniature.

PUT half a drachm of the phophorus into a large pint Florence flask, holding it slanting, that the phosphorus may not break the glass; pour upon it a gill and a half of water, and place the whole over a tea-kettle lamp, or any common tin lamp, filled with spirit of wine; light the wick, which should be almost half an inch from the flask: as soon as the water is heated, streams of fire will issue from the water by starts,

starts, resembling sky-rockets; some particles will adhere to the sides of the glass, and represent stars, and will frequently display brilliant rays. And these appearances will continue at times till the water begins to simmer, when immediately a curious aurora borealis begins, and gradually ascends till it collects to a pointed flame: when it has continued about half a minute, blow out the flame of the lamp, and the apex that was formed will rush down, forming beautiful illumined clouds of fire rolling over each other for some time, which disappearing, a splendid hemisphere of stars presents itself. After waiting a minute or two, light the lamp again, and nearly the same phenomena will be displayed as from the beginning. Let a repetition of lighting and blowing out the lamp be made for three or four times at least, that the stars may be increased; after the third or fourth time of blowing out the lamp, in a few minutes after the internal surface of the flask is dry, many of the stars will shoot with great splendour from side to side, and some of them will fire off with brilliant rays; and these appearances will continue several minutes. What remains in the flask will serve for the same experiment several times, and without adding any more water. Care should be taken, after the operation is over, to lay the flask and water in a cool secure place. In using the solid phosphorus, let a cup of water be always near you; and when you write any thing with it upon a wall, &c. do not keep it more than half a minute at a time in your hand, for fear the warmth of your hand should set it on fire. When you have wrote a few words with it, put the phosphorus into the cup of water, and let it stay a little to cool; you may then take it out, and write with it again. A stick of phosphorus put into a large dry phial not corked, will exhibit a light in the dark sufficient to discern any thing in a room when held near it.

Experiment 16.—If you mix about a tea spoonful of each of the numbers 21 and *2, and put it into a phial, you will produce a smelling salt; and if you add a few drops of water,

water, and shake the whole in a phial, it will be very pungent.

Write with a new pen with No. 13 any words you please, and let them dry, and they will be perfectly invisible; then write any other words or name over it with No. 14, observing to shake it well before you write with it, and it will seem as if written with common ink; when that is perfectly dry, pour a little of No. 15 on some tow, and with it wash off what was written with No. 14, and what was written with No. 13 will appear black.

Green ink. If you draw a tree on paper with bare branches, with a black-lead pencil, and with an hair pencil, or pen, form leaves on the branches with this ink; when it is perfectly dry, the leaves will not be discernible; but, upon warming the paper before the fire, the leaves will all appear of a beautiful green, as in summer: in about ten minutes they will disappear again, and represent winter: and by warming the paper again, the leaves will re-appear. This may be repeated several times at your pleasure. Observe not to put the paper before a fierce fire, lest you scorch it; and let it continue no longer before the fire than till the leaves appear plain.

A BRIEF ANALYSIS OF WATERS BY PRECIPITANTS.

THE clearness of water, equal to that of crystal, is a sign of pure water; on the contrary, a turbidness shews plainly that heterogeneous matters are so grossly mixed with it, as to obstruct the passage of the rays of light. When the bottom is clay or mud, the water is never perfectly clear; but when it runs over sand, it is in general very transparent. Good water is entirely without colour; but all colourless waters are not to be considered as good. A brown colour, verging to red or yellow, is found in dull stagnant waters; it is sometimes occasioned by iron, sometimes by putrid ex-

tractive matters, and sometimes perhaps is derived from some unctuous substance. A blue colour indicates a solution of copper; a green one, that of iron. If, upon agitation, water emits a number of airy bubbles, a quantity of aerial acid is inherent. Good water has no smell; such as abounds in aerial acid, diffuses a penetrating odour. Such as contains any hepar sulphur, yields a smell resembling that of rotten eggs, as Harrowgate water. Stagnant waters have a putrid offensive smell. A nice taste will distinguish the difference of several waters. Aerial acid occasions a gentle pungent acescent taste; a bitterness accompanies those waters which contain Glauber's salt, nitre, or magnesia; a slight austerity proceeds from lime and gypsum; a sweet astringency from alum; a saltishness from common salt; a lixivious flavour from alkali; a bitter astringency from copper; and an inky taste from iron. Syrup of violets has been a very universal test for waters containing acid and alkali, by their being changed either green or red, as in Experiments 3 and 4. This in general answers, except in chalybeate and aluminous waters. Tincture of galls, No. 7, shews iron in water by changing it purple or black, as in Experiments 9 and 10. If water contains any copper, it will be converted blue by dropping in a little of No. 3, as is shewn in Experiments 5 and 6. Phlogisticated alkali, No. 17, precipitates from water containing iron a Prussian blue, as in Experiment 13. If water contains any copper, this alkali precipitates a reddish brown colour. The fixed alkali, No. 2, precipitates magnesia from waters containing it, as in Experiments 7 and 8. A solution of soap separates all earthy matters, such as gypsum, lime, and magnesia, which are principally dissolved in hard water. A solution of silver in the acid of nitre, by a single drop, discovers whether there is any common salt in water by producing white striae. A solution of mercury in acid of nitre gives different precipitates. If waters are impregnated with caustic vegetable alkali, a yellowish white; if with mineral alkali, yellow, which soon grows white; if with volatile

volatile alkali, a greyish colour; with marine acid, common salt, and all other substances containing that acid, a white precipitate. Lime water dropped into any water containing the aerial acid, is by means of the fixed air converted into chalk.

By elective attraction is understood the power by which the constituent parts of bodies unite; but as the cause of the power is unknown to us, we must consider it only as a power of combination. It may be a simple affinity or attraction, as is exemplified in mixing water with water, oil with oil, &c. or it may be compound, by mixing heterogeneous bodies together. All bodies consisting of two or more constituent parts, may be said to be compounded by attraction: thus, sea water contains not only common salt, but magnesia, and other substances; and even common salt contains the marine acid and mineral alkali. Though many bodies do unite by attraction, yet there are other bodies that have a stronger attraction to one of the united bodies, than that which has been mixed with it: for if I pour strong sulphuric acid on common salt, the muriatic acid will be expelled, and the mineral alkali being united with the vitriolic acid, will form Glauber's salt. So Epsom salt readily dissolves in water which attracts it; but upon effusion of spirit of wine, the water having a stronger attraction to spirit of wine, quits the salt, which readily crystallizes at the bottom, as is exemplified in Experiment 12: but in this case the solution must be more diluted. Again, fixed alkaline salt, No. 2, has a stronger attraction to water; for if you add spirit of wine to the dry fixed alkaline salt, the watery particles will be extracted from the spirit of wine, and the salt will be dissolved after shaking them. If one ounce of sugar of lead is added to a pound of water, the curious zinc tree, as it is called, may be produced by means of this solution. A pint glass decanter is to be filled with the solution; a circular-shaped brass ring, suspended from the stopper, and to the upper extremity of this a lump, or small bullet of zinc, is to be fast-

 ened.

ened. The preparations being left for one evening, a very curious precipitation on the wire will take place, from the strong affinity that the zinc has to the acid.

Curious and singular Experiment.

If in a bottle, provided with a ground stopper, and filled with caustic spirit of ammoniac, a little copper filings be introduced, and the vessel be immediately stopped, without including any air, no solution ensues. On the contrary, if the bottle be left open for some time, and then closed, a solution is effected, which is absolutely colourless, but turns blue on re-opening the bottle, beginning at the surface, and gradually extending downwards through the whole mass. Again, if this blue solution has not been too long exposed to the air, and fresh copper filings be put in, stopping the bottle again, the solution is a second time deprived of all its tinge, and recovers its colour only by the admission of air.

To make the Arbor Dianæ.

If to the solution of silver in nitric acid a little quick-silver or mercury is added, the quick-silver will be dissolved, and the silver will fall down and form a resemblance of a tree called Arbor Dianæ, whose branches have the splendour of silver. The liquor will then be a solution of mercury; if you put a thin piece of lead into this last solution, the mercury will be precipitated in form of a calx or powder, and the liquor will be a solution of lead. If to this you add a thin slip of copper, the lead will fall down, and the copper be dissolved: if to this solution of copper you put in a clean iron nail, the iron will be dissolved, and the copper in precipitating will receive phlogiston, or the inflammable principle from the iron, and incrustate the nail with pure copper, as

as far as the liquor reaches. Absorbent earths and volatile alkali will precipitate the iron, and fixed alkali either of the other precipitants. The last solution will be only salt-petre or nitre dissolved in water.

Another Method.

THE experiment of the Arbor Dianæ may be exhibited in a beautiful way from the following directions: on a slip of glass, two inches long and one wide, lay a small quantity of the above solution of silver; then lay a small piece of brass or copper in the lower part, and you will see it vegetate into a beautiful sort of shrub immediately; then with a pencil draw a fluid stroke from the shrub, to the lower part of the glass, and it will form the body of the tree; and at the bottom a stroke may be drawn for the ground; then, shaking a few brass filings over the body of the ground, it will complete the tree. If to the slip of glass is put on another of brass, and held in a coal fire till it becomes red-hot, the silver tree will appear to be converted into a gold one. Under a glass magnifier, or microscope, the silver vegetation appears in a still more beautiful manner.

To effect many of these kind of changes you must allow a day or two, as some of the metallic bodies dissolve slowly, and the more so without heat. To procure copper from waters impregnated with it, they put in a quantity of old iron, and the copper will be precipitated in its own form, and requires only to be melted, as it receives phlogiston from the iron which loses it whilst it is dissolving. You may easily conceive this, by putting the point of a knife into a little of No. 5, in a glass, in a minute or two the part in contact with the liquor will be covered with a thin coat of copper; which is accounted for in the column of acid of

vitriol,

vitriol, that acid having a stronger attraction to iron than copper.

To make a Lead Tree.

No uniform combination of lead with zinc ever takes place; for these two metals do not chemically dissolve each other in fusion. Lead is precipitated by zinc from acids. Two drachms of acetite of lead are dissolved in six ounces of distilled water, the filtered solution is poured into a cylindrical glass, and a thin roll of zinc being hung in, the whole is left standing in repose. The lead precipitates, adhering to the zinc in metallic leaves in the form of a tree.

Another Method.

Dissolve an ounce of sugar of lead in a quart of clear water, and put it into a glass decanter or globe. Then suspend in the solution, near the top, a small piece of zinc of an irregular shape. Let it stand undisturbed for a day, and it will begin to shoot out into leaves, and apparently to vegetate. If left undisturbed for a few days, it will become extremely beautiful; but it must be moved with great caution. It may appear to those unacquainted with chemistry, that the piece of zinc actually puts out leaves; but this is a mistake, for if the zinc be examined, it will be found nearly unaltered. This phenomenon is owing to the zinc having a greater attraction for oxygen than the lead has; consequently, it takes it from the oxyde of lead, which re-appears in its metallic state.

Arbor Martis, or Tree of Mars.

Dissolve iron filings in aqua-fortis moderately concentrated, till the acid is saturated; then add to it gradually a solution

solution of fixed alkali, commonly called oil of tartar per deliquium. A strong effervescence will ensue, and the iron, instead of falling to the bottom of the vessel, will afterwards rise, so as to cover its sides, forming a multitude of ramifications heaped one upon the other, which will sometimes pass over the edge of the vessel, and extend themselves on the outside with all the appearance of a plant.

Changing Iron apparently into Copper.

Dissolve some blue vitriol (sulphate of copper) in water, and dip into the solution a piece of bright iron or steel; in a few seconds it may be taken out, when it will be apparently turned to copper. This is a deception: the iron is not changed into copper. It is only incrusted over with that metal, as may be easily seen by removing the copper by a file. The iron having a stronger attraction for sulphuric acid than copper, it takes the acid from the latter, which is consequently precipitated. This process is used for obtaining the copper from waters near mines that contain a great quantity of that metal. Iron plates are put into them, these become incrusted with copper, which is scraped off.

To prepare the Precipitate of Cassius.

This beautiful purple colour is extremely useful to enamellers and glass stainers. To make it, proceed as follows:

Dissolve some gold in aqua-regia (nitro-muriatic acid), and also dissolve some pure tin in diluted aqua-regia, and pour it into the solution of gold. A purple powder will be precipitated, which must be collected and washed in distilled water.

How

How to gild Ribbons.

IMMERSE a slip of white silk in a solution of nitro-muriate of gold in distilled water, and dry it in the air. Silk thus prepared, will not be altered by hydrogen gas; but if another piece of silk be dipped in the solution, and exposed while *wet* to the same current of hydrogen gas, instant signs of metallic reduction will appear; the colour will change from yellow to green, and a brilliant film of reduced gold will soon glitter on its surface.

Another Method.

IF flowers, or any other figures, be drawn upon a ribband or silk with a solution of nitrate of silver, and the silk, moistened with water, be then exposed to the action of hydrogen gas, the silver will be revived, and figures, firmly fixed upon the silk, will become visible, and shine with metallic brilliancy.

By proceeding in the same manner, and using a solution of gold in nitro-muriatic acid, silks may be permanently gilt.

Experiment on Phosphuret of Lime.

TAKE a small piece of phosphuret of lime, a little moistened by the air, and let a single drop of concentrated muriatic acid fall upon it. In this case phosphuretted hydrogen will also be evolved, accompanied by small balls of fire, darting from the mixture, and the most intolerable fetid smell that can be conceived.

Combustion under Water.

DROP a piece of phosphorus, about the size of a pea, into a tumbler of hot water, and from a bladder, furnished with a stop-cock, force a stream of oxygen directly upon it. This will afford the most brilliant combustion under water that can be imagined.

To make a Fountain of Fire.

IF twenty grains of phosphorus, cut very small, and mixed with forty grains of finely powdered zinc, be put into four drachms of water, and two drachms of concentrated sulphuric acid be added thereto, bubbles of inflamed phosphuretted hydrogen gas will quickly cover the whole surface of the fluid in succession, forming a real fountain of fire.

How to Dye Calico a Scarlet Colour.

DIP a piece of white calico in a strong solution of acetate of iron: dry it by the fire, and lay it aside for three or four days. After this, wash it well in hot water, and then dye it black, by boiling it for ten minutes in a strong decoction of Brazil wood. If the cloth be now dried, any figures printed upon it with a *colourless* solution of muriate of tin, will appear of a beautiful scarlet, although the ground will remain a permanent black.

To Dye Green which turns to Blue.

DISSOLVE four drachms of sulphate of iron, in one pint of cold water, then add about six drachms of lime in powder, and

and two drachms of finely pulverized indigo, stirring the mixture occasionally for twelve or fourteen hours. If a piece of white calico be immersed in this solution for a few minutes, it will be dyed green; and by exposure to the atmosphere only for a few seconds, this will be converted to a permanent blue.

Theory of Bleaching Linen.

If a few strips of dyed linen cloth, of different colours, be dipped into a phial of oxygenized muriatic acid, the colours will be quickly discharged; for there are few colours that can resist the energetic effect of this acid. This experiment may be considered as a complete example of the process of bleaching coloured goods.

Theory of Calico Printing.

If lemon juice be dropped upon any kind of buff colour, the dye will be instantly discharged. The application of this acid, by means of the block, is another method by which calico-printers give the white spots or figures to piece-goods. The crystallized acid, in a state of solution, is generally used for this purpose. These few experiments will give some idea of the nature of calico-printing.

Test of the Purity of Water.

Into distilled water, drop a little spirituous solution of soap, and no chemical effect will be perceived; but if some of the same solution be added to hard water, a milkiness will immediately be produced, more or less, according to the degree of its impurity. This is a good method of ascertaining the purity of spring water.

Test to discover the Presence of Sulphuric Acid.

TAKE a slip of blue litmus paper, dip it into acetous acid, and it will immediately become red. This is a test so delicate, that according to Bergman, it will detect the presence of sulphuric acid, even if the water contain only one part of acid, to thirty-five thousand parts of water.

Beautiful Instance of Sublimation.

INTO a large glass jar, inverted upon a flat brick tile, and containing near its top a branch of fresh rosemary, or any other such shrub, moistened with water, introduce a flat thick piece of heated iron, on which place some gum benzoin in gross powder. The benzoic acid, in consequence of the heat, will be separated, and ascend in white fumes, which will at length condense, and form a most beautiful appearance upon the leaves of the vegetable. This will serve as an example of sublimation.

To make Phosphorus.

PHOSPHORUS was formerly prepared from urine, and was therefore called *phosphorus of urine;* but it is exactly the same substance, from whatever materials it is procured. The following is a process for procuring it from bones, which consist chiefly of lime combined with the phosphoric acid.

Take a quantity of bones, burn them to whiteness in an open fire, and reduce them to a fine powder. Upon three pounds of this powder, after having been put into a mattrass, pour two pounds of concentrated sulphuric acid of com

merce;

merce; four or five pounds of water must be afterwards added by degrees, to assist the action of the acid. During the process, the operator must place himself and the vessel, so that the fumes of the mixture may be blown from him. The whole is then to be left in a sand bath for about twelve hours, or more, taking care to supply the loss of water which happens by evaporation. The next day, a large quantity of water must be added, the clear liquor must be decanted, and the rest strained through a cloth or sieve. The residuary matter is to be washed by repeated affusions of hot water till it passes tasteless. The water which has been used to wash out the adhering acid is mixed with the decanted or strained liquor, and the whole fluid is gradually evaporated in a flat earthen basin to the consistence of a syrup. It is then mixed with an equal weight of charcoal powder, and submitted to distillation in an iron or earthen retort. Instead of using a receiver, the neck of the retort may be immersed in a basin of water to a small depth, and the phosphorus, as it comes over, will fall in drops to the bottom.

Phosphorus made in this manner is blackish and dirty; it is purified by a second distillation. It may also be prepared from urine by the following method:

Dissolve as much lead in the nitric acid as it will act upon, and the solution will be nitrate of lead. Pour this into a quantity of urine, and a precipitate will be formed. When no more precipitate falls down by the addition of the solution, suffer the whole to stand undisturbed till it has all subsided, and then pour off the clear fluid. Make this precipitate into a paste with charcoal finely pounded, and dry it in an earthen pan gradually. Then put the mass into an iron or earthen retort, and distil it. The phosphorus will come over, and may be collected under water.

To make Canton's Phosphorus.

TAKE some oyster-shells; calcine them, by keeping them in a good fire for about an hour. Select out of the calcined shells the purest and whitest parts, and pound and sift them. To three parts of this lime, add one of flowers of sulphur; mix them well together, and put them well pressed into a crucible. Place it in a good fire, where it must be kept red hot for an hour at least; it may then be taken out to cool. When it is cold, break the mass to pieces, and select out of it the brightest part, which will shine in the dark.

A beautiful representation of the telescopic appearance of one of the planets may be made by means of this. Cut out in paper the shape of the planet, such as a half moon, Saturn, and his ring, &c. and cover it over with strong gum water; then strew some of this phosphorus, finely powdered, over the surface. When you want to exhibit it in the dark, you must previously expose it for a few mnutes to the light of an Argand's lamp; or, what is better, make the flash from the discharge of a large electrical jar, or battery, pass over its surface, and it immediately becomes luminous, and exhibits a very exact resemblance of the planet.

To make Phosphoric Oil,

PUT one part of phosphorus into six of olive-oil, and digest them over a sand heat. The phosphorus will dissolve. It must be kept well corked.

This oil has the property of being very luminous in the dark, and yet it has not sufficient heat to burn any thing. If rubbed on the face and hands, taking care to shut the eyes, the appearance is most hideously frightful; all the parts with which it has been rubbed, appear to be covered

with

with a very luminous lambent flame of a bluish colour, and the mouth and eyes appear in it as black spots. There is no danger attending this experiment. The light of it is sufficient to shew the hour of the night on a watch, by holding it close to the bottle when it is unstopped.

To make Phosphorated Lime.

PUT a few grains of phosphorus into the bottom of a Florence flask, and fill it up with quick-lime. Place it over a lamp till the phosphorus has sublimed, and is thoroughly mixed with the lime. If any of this lime be thrown out in the dark, it has the appearance of a shower of fire, but cannot burn any thing, as the quantity of phosphorus is too small to produce any sensible heat.

To make a Phosphoric Fire Bottle.

TAKE a very small phial, and put into it a bit of phosphorus as large as a pea, and fill up the bottle with lime. Fix an iron vessel, as a shovel, for instance, with common sand, and put it over the fire. Set the phial in this sand, having loosely stopped it with a cork. Stir about the ingredients with a wire, and mix them together, taking care that the phosphorus does not catch fire by too great an access of air. Keep the bottle in the sand till the phosphorus is thoroughly incorporated with the lime, when it will be of a reddish yellow.

This bottle is extremely convenient for procuring an instantaneous light in the dark. For this purpose, nothing more is necessary than to uncork the bottle, and to introduce a brimstone match, stirring it about a little, by which it will catch fire and light.

The

The bottle must be always kept carefully corked, and opened as seldom as possible.

A more durable kind may be made by uniting together one part of sulphur with eight of phosphorus. When this is used, a match is introduced into it, and then rubbed upon a bit of cork.

To make Phosphuret of Lime.

Put half an ounce of phosphorus, cut into small bits, into a glass tube about a foot long, and half an inch in diameter, closed at one end. Fill up with quick-lime grossly powdered, and stop the mouth of the tube loosely. Heat that part of the tube which contains the lime, over a chafing-dish, till it be red hot; and then apply the heat of a lamp to the part containing the phosphorus, which will sublime, and mix with the lime. When cooled, the mixture will be a reddish mass.

If phosphuret of lime be dropped into water, air bubbles will be disengaged, which, on bursting at the top, will inflame with small explosions. They consist of phosphorated hydrogen gas.

To make Fulminating Powder.

Triturate in a warm mortar three parts, by weight, of nitre, two of mild vegetable alkali (carbonate of potash), and one of flowers of sulphur. A few grains of this laid upon a knife, and held over the candle, first fuses, and then explodes with a loud report. A drachm of it put into a shovel, and held over the fire, makes a noise as loud as a cannon, and indents the shovel as if it had received a violent blow.

To make Fulminating Mercury.

DISSOLVE 100 grains of mercury with heat, in a measured ounce and a half of nitric acid. This solution being poured cold upon two measured ounces of alkohol, previously introduced into any convenient glass vessel, a moderate heat is to be applied till effervescence is excited. A white fume then begins to undulate on the surface of the liquor, and the powder will be gradually precipitated on the cessation of action. The precipitate is to be immediately collected on a filtre, well washed with distilled water, and cautiously dried in a heat not exceeding that of a water bath. The immediate washing of the powder is material, because it is liable to the re-action of the nitric acid; and while any of the acid adheres to it, it is very subject to the action of light. From 100 grains of mercury, about 120 or 130 of the powder are obtained.

This powder, struck on an anvil with a hammer, explodes with a stunning disagreeable report; and with such force as to indent both the hammer and the anvil. Three or four grains are as much as ought to used for such experiments.

To make a beautiful Blue.

ONE ounce of perfect oxyde of molybdena is boiled with sixteen ounces of water, till the liquor is reduced to one-third; it is then filtered, and half an ounce of it is poured into a small vessel of white glass, in which ten grains of tin-clippings were placed beforehand, upon this four drops of muriatic acid are added, and the whole is left standing quietly. A beautiful blue colour is soon produced, rising upwards from the bottom, where it begins, and gradually assuming

assuming a deeper and deeper tinge. This solution deposits in time a blue precipitate. When the solution of muriat of tin, which holds this metal as imperfectly oxyded as possible, is precipitated by dissolved molybdat of pot-ash, both solutions having been previously diluted with a large quantity of distilled water, a beautiful blue precipitate is obtained, which Richter calls blue carmine.

How to make a Sky-Blue Colour.

THE oxyd of copper is dissolved with very great ease by ammoniac. If no more liquid ammoniac be dropped into a solution of copper in acids than is necessary to saturate the acid, the precipitate falls down of a pale blueish green. By an over proportion of ammoniac, the precipitate is tinged blue, and totally dissolved by it. The solution presents a beautiful azure, or sky-blue colour.

Method of making a fine Green Colour.

A FINE green colour for painters may be obtained from the oxyds of these two metals: cobalt ore dissolved in nitro-muriatic acid is mixed with $1\frac{1}{2}$ as much of nitrat of zinc; a lixivium of pot-ash is then added, and the precipitate is ignited to whiteness.

How to make Naples Yellow.

TWELVE parts of white-lead, three of perfect oxyd of antimony, one of sulphat of alumine, and one of muriat of ammoniac, well triturated and mingled, if first heated weakly for some hours, and then more strongly for a like space of time, to the redness of the crucible, afford, after cooling,

 by

by levigation, the fine metallic pigment called Naples yellow.

To make Patent Yellow.

For this purpose three parts of red-lead are dissolved in one part of common salt and $\frac{1}{10}$th of burnt lime; and these ingredients are left in a stopped bottle for some time, shaking it now and then. After lixiviation, the lye contains caustic mineral alkali, or pure soda, together with some muriat of lead; and the residue holds muriat of lead, which, by roasting in a moderate heat, is converted into a greenish yellow pigment, (patent yellow).

To make Green Paint.

Carbonat of copper (carbonated oxyd of copper) is very easily procured, if copper dissolved in acids be precipitated by means of the carbonats of pot-ash or soda. This precipitate exhibits a bright green colour, and is soluble in water. It may serve to prepare various green pigments for painters.

How to make Verditer.

The artificial mountain blue, or verditer (caeruleum montanum), belongs also to the precipitated oxyds of copper. The method of preparing it, recommended by Pelletier, is this: pure copper is dissolved in weak nitric acid, powdered quick-lime is presented to the solution, and the mixture well stirred; when all the precipitate has subsided it is washed with clean water; and lastly, it is levigated, while yet moist, adding from five to ten parts of quick-lime to 100 parts of the precipitate.

How

How to make Verdigris.

If plates of copper, moistened from time to time with vinegar, be left exposed to the air, they will be converted into a green oxyd, an example of which is furnished by verdigris. This is an imperfect oxyd of copper, combined with a small portion of acetic acid, carbonic acid, and water. It is prepared in large quantities chiefly in France, near Montpellier, by stratifying copper-plates with the husks of grapes, yet under vinous fermentation, which soon grow acid, and corrode the copper. After the plates have stood in this situation for a sufficient time, they are moistened with water, and exposed in heaps to the air. The verdigris is scraped off from their surface, as it forms.

How to make Tuttenag, &c.

Bismuth and tin combine readily by fusion, and the tin is by bismuth rendered harder, more brittle, still more easily fusible, and at the same time more sonorous. Two parts of tin with one part of bismuth, afford the compound called Tuttenag: an appellation which in the East-Indies is given to zinc. Tin, bismuth, and lead, melted together, give very fusible metallic mixtures, serving to organ-builders and pewterers as soft solders. The most fusible of these compositions is obtained, according to D'Arcet, from eight parts of bismuth, five of lead, and three of tin; it melts at a heat not greater than that of boiling water, and becomes thereby as fluid as mercury. When refrigerated it is brittle, but not hard, of a grained texture, and soon loses its brightness in the air. That of rose, made by two parts bismuth, one lead, one tin, has been mentioned. Because the muriatic-acid

does not dissolve bismuth, the tin is separable from this latter by means of that acid.

The substance produced by combining equal parts of bismuth, tin, and mercury, is called argentum musivum. According to Dessie, the tin is first exposed to heat, and when it begins to melt, the bismuth is added. When completely incorporated by fusion and stirring, they are removed from the fire to become a little cooler; but while yet hot the mercury is added by stirring. After which the whole is poured on a stone, and as the matter cools it forms a metallic paste, which may easily be bruised into a flaky powder. Its use is the same as that of the aurum musivum.

How to Tin Iron Plates.

Tin and iron may be fused into one mass, if they be introduced by layers in a melting-pot lined with charcoal dust, if the uppermost stratum likewise consists of charcoal, and if the pot is covered with its lid, and thus circumstanced, they be fused in a sufficiently strong forge heat. Tin that contains but little iron continues tractable, but is rendered somewhat harder, of a deeper colour, and more refractory in fusion. Tin, on the contrary, alloyed with but one half of its weight of iron, shews the properties of iron in an eminent degree. Iron, whose surface is purely reguline, may be tinned, as is shewn by those plates of iron coated with tin, and which are generally distinguished by the simple name of tin alone.

Of these tinned iron plates, various kitchen vessels, now in common use, and other useful utensils, are manufactured. They are prepared for tinning like copper, and then plunged into a vessel containing melted tin, whose surface is covered with tallow or other fat, to prevent the metal from oxydation.

To

To make Tombac, &c.

TOMBAC, prince's metal, and similor, are species of yellow copper. All of them contain a less quantity of zinc than enters into the composition of brass; hence their colour is of a deeper hue. They are made either by melting together copper and zinc in the direct way in proper proportions, or by combining brass with a fresh portion of copper.

Tombac, and another alloy of the same kind, called Pinchbeck, have received their names from two English artists. The prince's metal was invented by a Palatine prince of the name of Rupert, who was an English admiral, and died in 1682. As to colour, the prince's metal is the palest, and has therefore the most of zinc: Pinchbeck is redder, and has more copper: Tombac is of the deepest reddish hue; the proportion of copper is therefore still increased, and that of zinc diminished. The finest of all is the Similor, also called Manheim gold, in colour like gold, and resembling Pinchbeck. From this the spurious leaf-gold, laces, and other articles, are manufactured; and for making laces, &c. it is mostly gilt.

Method of tinning Brass Pins.

HERE also may be taken notice of the tinning of brass pins, because it is properly the zinc of the brass, and not the copper, which precipitates the dissolved tin in the reguline state. A vessel is filled by layers with plates of tin and brass pins, a tin plate being uppermost and undermost. The vessel is then filled with water, adding some cream of tartar, by whose acid the tin is dissolved. After five hours boiling the pins are found uniformly tinned.

How

How to make Printer's Types.

LEAD and antimony afford a white, brittle, metallic alloy, whose brittleness increases as the portion of lead diminishes. The metal of which printer's types are cast principally consists of this compound, commonly in the proportion of 80 parts of lead to from 15 to 25 of antimony, with or without the addition of either zinc or bismuth. Antimony is not vitrified by lead on the cupel, but it produces a sparkling with the litharge, and is thrown over the borders of that vessel in the form of oxyd. On this account gold or silver containing antimony cannot be refined by cupellation.

Method of making Ship-Nails.

A MELTED mixture of three parts tin, two parts lead, and one of antimony, is said to be very useful for making ship-nails.

Frigorific Mixtures.

GREAT degrees of cold are produced by mixing together substances which dissolve rapidly. The reason of this will appear when it is recollected from facts already noticed, that in the conversion of solid bodies into fluids, caloric is always absorbed. Mixtures to produce artificial cold are generally made of the neutral salts dissolved in water; of diluted acids, and some neutral salts; and of snow or pounded ice, with some of these. The public is indebted to Fourcroy and Vauquelin, of France; and to Professor Lowitz, of Petersburgh, for a great variety of experiments on this subject. But our own countryman, Mr. Richard Walker, of Oxford, has done more on the article of frigo-

rific

rific mixtures than any other man. To this gentlemen one of the editors of the present work is indebted for a correct account of the result of his many excellent experiments, which will be given in the following tables: these were transmitted for the express purpose of preventing a repetition of errors which have crept into some popular modern works of authority.

TABLE

TABLE I.

This table consists of frigorific mixtures, which are sufficient for all useful and philosophical purposes, in any part of of the world, at any season.

Frigorific Mixtures, *without Ice.*

Mixtures.	Thermometer sinks.	Degr. of cold produced.
Muriate of ammonia •• 5 parts Nitrate of potash•••••• 5 Water •••••••••••••• 16	From $+50^{\circ}$ to $+10^{\circ}$.	40
Muriate of ammonia •• 5 parts Nitrate of potash•••••• 5 Sulphate of soda •••••• 8 Water •••••••••••••• 16	From $+50^{\circ}$ to $+4^{\circ}$	46
Nitrate of ammonia •• 1 part Water •••••••••••••• 1	From 50° to $+4^{\circ}$.	46
Nitrate of ammonia•••• 1 part Carbonate of soda •••• 1 Water •••••••••••••• 1	From $+50^{\circ}$ to -7°.	57
Sulphate of soda •••••• 3 parts Diluted nitric acid •••• 2	From $+50^{\circ}$ to -3°.	53
Sulphate of soda •••••• 6 parts Muriate of ammonia •• 4 Nitrate of potash•••••• 2 Diluted nitric acid •••• 4	From $+50^{\circ}$ to -10°.	60
Sulphate of soda•••••• 6 parts Nitrate of ammonia •• 5 Diluted nitric acid •••• 4	From $+50^{\circ}$ to -14°.	64
Phosphate of soda •••• 9 parts Diluted nitric acid •••• 4	From $+50^{\circ}$ to -12°.	62
Phosphate of soda •••• 9 parts Nitrate of ammonia •• 6 Diluted nitric acid •••• 4	From $+50^{\circ}$ to -21°.	71
Sulphate of soda•••••• 8 parts Muriatic acid •••••••• 5	From $+50^{\circ}$ to 0°.	50
Sulphate of soda•••••• 5 parts Diluted sulphuric acid . 4	From $+56^{\circ}$ to $+3^{\circ}$.	47

N. B. If the materials are mixed at a *warmer* temperature, than that expressed in the table, the effect will be proportionably *greater*; thus, if the most powerful of these mixtures be made, when the air is $+85^{\circ}$, it will sink the thermometer to $+2^{\circ}$.

TABLE II.

This Table consists of frigorific mixtures, composed of *ice*, with chemical salts and acids.

Frigorific Mixtures, *with Ice*.

Mixtures.		Thermometer sinks.	Deg. of cold produced.
Snow, or pounded ice .. Muriate of soda	2 parts 1	*From any Temperature*, to —5°	*
Snow, or pounded ice .. Muriate of soda ...... Muriate of ammonia ..	5 parts 2 1	to —12°	*
Snow, or pounded ice .. Muriate of Soda ...... Muriate of ammonia .. Nitrate of potash	24 parts 10 5 5	to —18°	*
Snow, or pounded ice .. Muriate of soda ...... Nitrate of ammonia	12 parts 5 5	to —25°	*
Snow .... Diluted sulphuric acid .	3 parts 2	From +32° to —23°	55
Snow .... Muriatic acid	8 parts 5	From +32° to —27°	59
Snow .... Diluted nitric acid	7 parts 4	From +32° to —30°	62
Snow .... Muriate of lime	4 parts 5	From +32° to —40°	72
Snow .... Christ. muriate of lime	2 parts 3	From +32° to —50°	82
Snow .... Potash	3 parts 4	From +32° to —51°	83

N. B. The reason for the *omissions* in the last column of this table, is, the thermometer sinking in these mixtures to the degree mentioned in the preceding column, *and never lower*, whatever may be the temperature of the materials at mixing.

TABLE III.

This Table consists of frigorific mixtures selected from the foregoing tables, and *combined*, so as to *increase* or *extend* cold to the extremest degrees.

Combinations of Frigorific Mixtures.

Mixtures.		Thermometer sinks.	Degr. of cold produced.
Phosphate of soda .... Nitrate of ammonia.... Diluted nitric acid	5 parts 3 4	From 0° to 34—°	34
Phosphate of soda .... Nitrate of ammonia .. Diluted mixed acids ..	3 parts 2 4	From —34° to —50°	16
Snow................ Diluted nitric acid	3 parts 2	From 0° to —46°	46
Snow................ Diluted sulphuric acid .. Diluted nitric acid	8 parts 3 } 3 }	From —10° to —56°	46
Snow................ Diluted sulphuric acid .	1 part 1	From —20° to —60°	40
Snow .... Muriate of lime	3 parts 4	From +20° to —48°	68
Snow .... Muriate of lime	3 parts 4	From +10° to —54°	64
Snow .... Muriate of lime	2 parts 3	From —15° to —68°	53
Snow .... Chryst. muriate of lime	1 part 2	From 0° to —66°	66
Snow .... Chryst. muriate of lime	1 part 3	From —40° to —73°	33
Snow .... Diluted sulphuric acid .	8 parts 10	From —68° to —91°	23

N. B. The materials in the first column, are to be cooled previously to mixing, to the temperature required, by mixtures taken from either of the preceding tables.

Mode of detecting the Adulteration of Pot-ash, Pearl-ash, and Barilla.

Few objects of commerce are adulterated to a greater extent than the alkalis, to the great loss and injury of the bleacher, the dyer, the glass-maker, the soap-boiler, and of all other artists, who are in the habit of employing these substances.

To discover whether any quantity of fixed alkali worth attention exists in a saline compound, dissolve one ounce of it in boiling water, and into this solution let fall a drop of a solution of sublimate corrosive; this will be converted into a brick colour, if an alkali be present, or into a brick colour mixed with yellow, if the substance tried contains lime.

But the substances used by bleachers being always impregnated with an alkali, the above trial is in general superfluous, except for the purpose of detecting lime. The quantity of alkali is therefore what they should chiefly be solicitous to determine, and for this purpose:

1st. Procure a quantity of alum, suppose one pound, reduce it to powder, wash it with cold water, and then put it into a tea-pot, pouring on it three or four times its weight of boiling water.

2dly. Weigh an ounce of the ash or alkaline substance to be tried, powder it, and put it into a florence flask with one pound of pure water (common water boiled for a quarter of an hour, and afterwards filtered through paper, will answer) if the substance to be examined be of the nature of barilla, or potash; or half a pound of water if it contain but little earthy matter, as pearl-ash: let them boil for a quarter of an hour: when cool let the solution be filtered into another florence flask.

3dly. This being done, gradually pour the solution of alum hot into the alkaline solution also heated; a precipitation

tion will immediately appear; shake them well together, and let the effervescence, if any, cease before more of the aluminous solution be added; continue the addition of the alum until the mixed liquor, when clear, turns syrup of violets, or paper tinged blue by raddishes, or by litmus, red; then pour the liquor and precipitate on a paper filter placed in a glass funnel. The precipitated earth will remain on the filter; pour on this a pound or more of hot water gradually, until it passes tasteless; take up the filter, and let the earth dry on it until they separate easily. Then put the earth into a cup of Staffordshire ware, place it on hot sand, and dry the earth until it ceases to stick to glass or iron; then pound it, and reduce it to powder in the cup with a glass pestle, and keep it a quarter of an hour in a heat of from 470° to 500°.

4thly. The earth being thus dried, throw it into a florence flask, and weigh it; then put about one ounce of spirit of salt into another flask, and place this in the same scale as the earth, and counterbalance both in the opposite scale: this being done, pour the spirit of salt gradually into the flask that contains the earth; and when all effervescence is over (if there be any) blow into the flask, and observe what weight must be added to the scale containing the flasks, to restore the equilibrium; subtract this weight from that of the earth, the remainder is a weight exactly *proportioned* to the weight of mere alkali of that particular species which is contained in one ounce of the substance examined; all beside is superfluous matter.

It has been said that alkalies of the *same species* may thus be directly compared, because alkalies of *different* species cannot but require the intervention of another proportion; and the reason is, because *equal* quantities of alkalies of different species precipitate *unequal* quantities of earth of alum. Thus 100 parts by weight of mere *vegetable* alkali, precipitate 78 of earth of alum; but 100 parts of *mineral* alkali precipitate 170, 8 parts of that earth. Therefore the precipitation of

of 78 parts of earth of alum by vegetable alkali, denotes as much of this as the precipitation of 170,8 of that earth by the mineral alkali denotes of the mineral alkali. Hence the quantities of alkali in all the different species of pot-ashes, pearl-ashes, weed or wood-ashes, may be immediately compared by the above test, as they all contain the vegetable alkali; and the different kinds of kelp or kelps manufacted in different places, and the different sorts of barilla, may thus be compared, because they all contain the mineral alkali. But kelps and pot-ashes, as they contain different sorts of alkali, can only be compared together by means of the proportion above indicated. See Transactions of the Irish Academy, 1789.

Mode of detecting the Adulteration of Manganese.

The principal defect of manganese arises from the admixture of chalk, which is not always an intentional adulteration; but is sometimes found united with it, as it occurs in the earth. When to this impure manganese, mixed with muriate of soda, the sulphuric acid is added, the materials effervesce and swell considerably; and a large proportion passes into the receiver, in consequence of which the bleaching liquor is totally spoiled. This misfortune has frequently happened; and can only be prevented by so slow and cautious an addition of the acid, as is nearly inconsistent with the business of an extensive bleaching work. The presence of carbonate of lime may be discovered in manganese, by pouring, on a portion of this substance, nitric acid diluted with eight or ten parts of water. If the manganese be good, no effervescence will ensue; nor will the acid dissolve any thing; but if carbonate of lime be present, it will be taken up by the acid. To the solution, add a sufficient quantity of carbonate of potash to precipitate the lime; wash the sediment with water, and dry it. Its weight will shew, how much chalk the manganese under examination contained.

Application

Application of Chemical Tests to the Uses of the Farmer, &c.

The benefits that might be derived, from the union of chemical skill with extensive observation of agricultural facts, are, perhaps, incalculable. At present, however, the state of knowledge, among farmers, is not such, as to enable them to reap much advantage from chemical experiments: and the chemist has, himself, scarcely ever opportunities of applying his knowledge to practical purposes, in this way. It may, perhaps, be of use to offer a few brief directions for the analysis of marls, lime-stones, &c.; and, on this occasion, we shall be indebted to the writings of Mr. Kirwan, for our principal information *.

Lime.

It is impossible to lay down any general rules respecting the fitness of lime for the purposes of agriculture, because much must depend on the peculiarities of soil, exposure, and other circumstances. Hence a species of lime may be extremely well adapted for one kind of land, and not for another. All that can be accomplished by chemical means, is to ascertain the degree of purity of the lime, and to infer, from this, to what kind of soil it is best adapted. Thus a lime, which contains much argillaceous earth, is better adapted, than a purer one, to dry and gravelly soils; and stiff clayey lands require a lime as free as possible from the argillaceous ingredient.

* See "The Manures most advantageously applicable to the various sorts of soils; and the causes of their beneficial effects in each particular instance;" by R. Kirwan, Esq.

To

To determine the purity of lime, let a given weight be dissolved in diluted muriatic acid. Let a little excess of acid be added, that no portion may remain undissolved, owing to the deficiency of the solvent. Dilute with distilled water; let the insoluble part, if any, subside; and the clear liquor be decanted. Wash the sediment with further portions of water, and pour it upon a filtre previously weighed. Dry the filtre, and ascertain its increase of weight, which will indicate how much insoluble matter, the quantity of lime, submitted to experiment, contained. It is easy to judge, by the external qualities of the insoluble portion, whether argillaceous earth abounds in its composition.

There is one earth, however, lately found in several limestones, which is highly injurious to the vegetation of plants, and is not discoverable by the foregoing process, being, equally with lime, soluble in muriatic acid. This earth is magnesia, which, by direct experiments, has been ascertained to be extremely noxious to plants. It is said, that a large proportion, instead of increasing, diminishes the fertility of the soil, and that whenever a heap of it is left in one spot, all fertility is prevented for many years. Fifty or sixty bushels, on an acre, are considered at Doncaster to be as much as could be used with advantage. The other sort of lime, according to Mr. Tenant, which was obtained from a village near Ferrybridge, though considerably dearer, from the distant carriage, was more frequently employed on account of its superior utility. A large quantity was never found to be injurious; and the spots, which were covered with it, instead of being rendered barren, became remarkably fertile. On examining the composition of these two species of lime, the fertilizing one proved to consist entirely of calcareous earth; and the noxious one of three parts lime and two magnesia.

The presence of magnesia in lime proved, on further investigation, to be a very common occurrence. The magnesian lime-stone appears to extend for thirty or forty miles, from

from a little south-west of Worksop, in Nottinghamshire, to near Ferrybridge, in Yorkshire; and it has also been found at Breedon and Matlock, in Derbyshire.

The magnesian lime-stone, may easily be distinguished, from that which is purely calcareous, by the slowness of its solution in acids, which is so considerable, that even the softest kind of the former is much longer in dissolving than marble. It has, also, frequently a crystallized structure, and sometimes, though not always, small black dots may be seen dispersed through it. In the countries, where this lime-stone is found, the lime is generally distinguished, from its effects in agriculture, by the farmers, as *hot* lime, in opposition to the purely calcareous, which they term *mild*.

To ascertain, by chemical means, the composition of a lime or lime-stone, suspected to contain magnesia, the following is the easiest, though not the most accurate process. Procure a florence flask, clean it well from oil by a little soap-lees, or salt of tartar and quick-lime mixed; and break it off, about the middle of the body, by setting fire to a string tied round it, and moistened with oil of turpentine. Into the bottom part of this flask, put 100 grains of the lime or lime-stone; and pour on it, by degrees, half an ounce of strong sulphuric acid. On each effusion of acid a violent effervescence will ensue; when this ceases, stir the acid and lime together with a small glass tube or rod, and place the flask in an iron pan filled with sand. Set it over the fire, and continue the heat till the mass is quite dry. Scrape off the dry mass, weigh it, and put it into a wine glass, which may be filled up with water. Stir the mixture, and when it has stood half an hour, pour the whole on a filtering paper, placed on a funnel, and previously weighed. Wash the insoluble part with water, as it lies on the filtre; and add the washings to the filtered liquor. To this liquor add a solution of half an ounce of salt of tartar in water, when, if magnesia be present, a very copious white sediment will ensue; if lime only, merely a slight milkiness. In the former case

case heat the liquor, by setting it in a tea cup, near the fire; let the sediment subside, pour off the clear liquor, which may be thrown away; and wash the white powder repeatedly with warm water. Then pour it on a filtre of paper, the weight of which is known, dry it, and weigh. The result, if the lime-stone has been submitted to experiment, shews how much carbonate of magnesia was contained in the original stone; or, deducting 60 per cent., how much pure magnesia 100 parts of the lime-stone contained. If the burnt lime has been used, deduct from the weight of the precipitate 60 per cent.; and the remainder will give the weight of the magnesia in each 100 grains of the burnt lime.

Analysis of Marls.

The ingredient of marls, on which their fitness for agricultural purposes depends, is the carbonate of lime. It is owing to the presence of this earth that marls effervesce on the addition of acids, which is one of their distinguishing characters. In ascertaining whether an effervescence takes place, let the marl be put into a glass partly filled with water, which will expel a portion of air contained mechanically in the marl: and thus obviate one source of fallacy. When the marl is thoroughly penetrated by the water, add a little muriatic acid or spirit of salt. If a discharge of air should ensue, the marly nature of the earth is sufficiently established.

To find the composition of a marl, pour a few ounces of diluted muriatic acid into a florence flask, place them in a scale, and let them be balanced. Then reduce a few ounces of dry marl into powder; and let this powder be carefully and gradually thrown into the flask, until, after repeated additions, no further effervescence is perceived. Let the remainder of the powdered marl be weighed, by which the quantity projected will be known. Let the balance be then restored.

restored. The difference of weight, between the quantity projected, and that requisite to restore the balance, will shew the weight of air lost during effervescence. If the loss amount to 13 per cent. of the quantity of marl projected, or from 13 to 32 per cent. the marl assayed is calcareous marl, or marl rich in calcareous earth.

Clayey marls, or those in which the argillaceous ingredient prevails, lose only 8 or 10 per cent. of their weight, by this treatment; and sandy marls about the same proportion. The presence of much argillaceous earth may be judged, by drying the marl, after being washed with spirit of salt, when it will harden and form a brick.

To determine, with still greater precision, the quantity of calcareous earth in a marl, let the solution in muriatic acid be filtered and mixed with a solution of carbonate of potash, till no further precipitation appears. Let the sediment subside, wash it well with water, lay it on a filtre, previously weighed, and dry it. The weight of the dry mass will shew how much carbonate of lime the quantity of marl, submitted to experiment, contained.

Analysis of Soils.

THE following rules, for determining the composition of a soil, are copied from the interesting tract of Mr. Kirwan already referred to.

1mo. In dry weather, when the soil is not over moist nor dry, let a surface of 16 square inches be cut through to the depth of 8 inches; this may be effected by a right angled spade, formed for this particular purpose. Of the parallelopiped thus dug up, the two inches next the surface should be cut off to get rid of the grass, and the greater part of the roots; we shall then have a solid 6 inches long, and 16 square at the end = 96 cubic inches. Let this be weighed; its weight will serve to find the specific gravity of the soil; for if

if 96 cubic inches weigh n pounds, 1728 (a cubic foot) should weigh x pounds, and x divided by 75,954 will express by the quotient the specific gravity of the soil. To render this and the subsequent operations more intelligible, I shall illustrate each by an example: Suppose the 96 cubic inches to weigh 6,66 pounds, then 1728 cubic inches should weigh

$$120 \text{ lb. and } \frac{120}{75{,}954} = 1{,}579.$$

2°. The earth being weighed, is next to be broken down and freed from all stony substances above the size of a pippin, and the remainder well mixed together, to render the whole as homogeneous as possible; then weigh the stones that were picked out, and find the proportion belonging to each pound of the residuary earth; call this the *stoney supplement*, and denote it by *S*. Thus if the stones weigh 1lb.=12 oz. the remainder, or mere earth, must weigh 5,66lb.; and if to 5,66lb. there belong 12 ozs. of stone, to 1lb. must belong 2,12014 ozs. or 2 ozs. 57,66 grs.=1017,66 grs. This then is the stony supplement of each succeeding pound=S.

3°. Of the earth thus freed from stoney matter, take 1lb. —*S*. (that is the above case 1lb.—2 oz. $57\frac{2}{3}$ grs.) heat it nearly to redness in a flat vessel, often stirring it for half an hour, and weigh it again when cold. Its loss of weight will indicate the quantity of water contained in 1lb. of the soil. Note this loss, and call it the *watery supplement*=*W*. Suppose it in this case 100 grains.

4°. Take another pound of the above mass, freed from stones, deducting the stony and watery supplements; that is, 1lb.—S—W, or in the above case 1lb.—2 ozs. $57\frac{2}{3}$ grs. for stone, and—100 grs. for water: consequently 1lb.—2 ozs. $157\frac{2}{3}$ grs. reduce it to powder: boil it in four times its weight of distilled water for half an hour; when cool, pour it off, first into a coarse linen filtre to catch the fibrous particles of roots, and then through paper, to catch the finer clayey particles diffused through it: set by the clear water,

 add

add what remains on the filtre to the boiled mass: if it be insipid, as I suppose it to be, then weigh the fibrous matter, and call it the *fibrous supplement*=F. Suppose it in the example in hand to weigh 10 grs.

5°. Take two other pounds of the mass freed from stony matter, No. II. substracting from them the weight of the stony, watery, and fibrous substances already found: that is, 2lb.—2S—2W—2F; pour twice their weight of warm distilled water on them, and let them stand twenty-four hours or longer; that is, until the water has acquired a colour, then pour it off and add more water as long as it changes colour; afterwards filtre the coloured water and evaporate it to a pint, or half a pint; set it in a cool place for three days, then take out the saline matter, if any be found, and set it by.

6°. Examine the liquor out of which the salts have been taken; if it does not effervesce with the marine acid, evaporate it to dryness, and weigh the residuum; if it does effervesce with acids, saturate it with the vitriolic or marine, and evaporate it to one fourth of the whole: when cool, take out the saline residuum, evaporate the remainder to dryness, and weigh it: this gives the coaly matter, which may be tried by projecting it on melted nitre, with which it will deflagrate. The half of this coaly matter call the *coaly supplement* of 1lb. I shall suppose it to amount to 12 grs. and denote it by C.

7°. The filtred water, No. IV. is next to be gently evaporated to nearly one pint, and then suffered to rest for three days in a cool place, that it may deposit its saline contents, if it contains any; and these being taken out, the remainder must be evaporated nearly to dryness, and its saline and other contents examined. How this should be done, I shall not mention, the methods being too various, tedious, and of too little consequence; few salts occur except gypsum, which is easily distinguished. The water may be examined as to its saline contents when it is evaporated to a pint; if

any salts be found, call them the *saline supplement*, and denote them by *S*. I shall suppose them here=4 grains.

8°. We now return to the boiled earthy residuum, No. IV. which we shall suppose fully freed from its saline matter, as, if it be not, it may easily be rendered so, by adding more hot water: let it then be dried as in No. III. is mentioned. Of this earthy matter thus dried, weigh off one ounce, deducting one-twelfth part of each of the supplements *S.W.F.C.* and *S*; that is, in this

$$\text{case}\frac{1017,66}{12}=84,4054\frac{100}{12}=8,333+\frac{10}{12}$$

$$=8,333+\frac{12}{12}=1+\frac{4}{12}=0,3333=95\text{ grs.}$$

in all—then 480—95=385 grains will remain, and represent the mere earthy matter in an ounce of the soil.

9°. Let this remainder be gradually thrown into a Florence flask, holding one and an half as much spirit of nitre as the earth weighs, and also diluted with its own weight of water (the acids employed should be freed from all contamination of the vitriolic acid); the next day the flask with its contents being again weighed, the difference between the weights of the ingredients and the weights now found, will express the quantity of air that escaped during the solution. Thus in the above case, the earth weighing 385 grains, the acid 577,5 grains, and the water 577,5 grains, in all 1540 grains, the weight after solution should also be 1540, if nothing escaped; but if the soil contains calcareous matter, a loss will always be found after solution. Let us suppose it to amount to 60 grains.

The weight of air that escaped, furnishes us with one method of estimating the quantity of calcareous matter contained in the earth essayed; for mild calx generally contains 40 per cent. of air; then if 40 parts air indicate 100 of calcareous matter, 60 parts air will indicate 150.

10°. The

10°. The solution is then to be carefully poured off, and the undissolved mass washed and shaken in distilled water; the whole thrown on a filtre, and washed as long as the water that passes through has any taste. The contents of this water should be precipitated by a solution of mild mineral alkali: this precipitate also being washed and dried in a heat below redness, should then be weighed. Thus we have another method of finding the weight of the calcareous matter.

11°. The undissolved mass is next to be dried in the heat already mentioned, and the difference between its weight and the weight of the whole earthy mass before solution should be noted, as it furnishes a third method of discovering the weight of the calcareous matter of which it is now deprived. Supposing this to amount to 150 grains, the weight of the undissolved residuum should in the above case be 383—150 =235 grains.

12°. Reduce the dried mass into the finest powder, throw it into a Florence flask or glass retort, and pour on it three times its weight of pure oil of vitriol, digest in a strong sand heat, and at last raise the heat so as to make the acid boil; afterwards let it evaporate nearly to dryness: when cold, pour on it gradually six or eight times its weight of distilled water, and, after some hours, pour off the solution on a filtre; the filtre should previously be weighed, and its edges soaked in melted tallow; the substance found on the filtre being weighed (substracting the weight of the filtre) gives the quantity of silicious matter; and this weight substracted from that of the dried mass, gives that of the argill. In this case I will suppose the silicious mass to weigh 140 grains, then the argillaceous should weigh 95 grains.

Then the composition of one pound of the soil is as follows:

Stony

Stony matter - - - - -			1017,66
Water - - - - - -			100
Fibres of roots - - - -			10
Soluble coal - - - - -			12
Saline matter - - - - -			4
Silex - - -	140 ×	12=	1680
Argill - - -	95 ×	12=	1140
Mild calx - -	150 ×	12=	1800
			5763,66+

And in centesimal proportion

Stony matter - -	18	
Fine silicious - -	29	
		47
Argill - - - - -		22
Mild calx - - - -		31
		100

Its retentive power is 82,25: hence I should judge it to be unfertile in this climate, unless situated on a declivity, with an unimpeded fall. It may be called a *clayey loam.*

Mr. Young discovered a remarkable circumstance attendant on fertile soils: he found that equal weights of different soils, being dried and reduced to powder, afforded quantities of air by distillation somewhat corresponding to the ratios of their values. This air was a mixture of fixed and inflammable airs, both proceeding, most probably, from the decomposition of water by the coaly matter in the soil. The distillation should be made from a retort glazed on the outside. He found an ounce of dry soil, value five shillings, produced, ten ounce measures;

Of value of from 5 to 12s. produced 28 oz.

	12—20	42
above	20	66

This appears to be a good method of estimating the proportion of coaly matter in soils that are in full heart; that is, not

not exhausted, and freed from roots, &c. Another mark of the goodness of a soil is the length of the roots of wheat growing in it; for these are an inverse proportion to each other, as, if the land be poor, the wheat will extend its roots to a great distance in quest of food; whereas, if it be rich, they will not extend above five or six inches.

END OF VOL. I.

Law and Gilbert, Printers, St. John's Square, London.